UNIV. OF MICH.
DEC 7 1906

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1614

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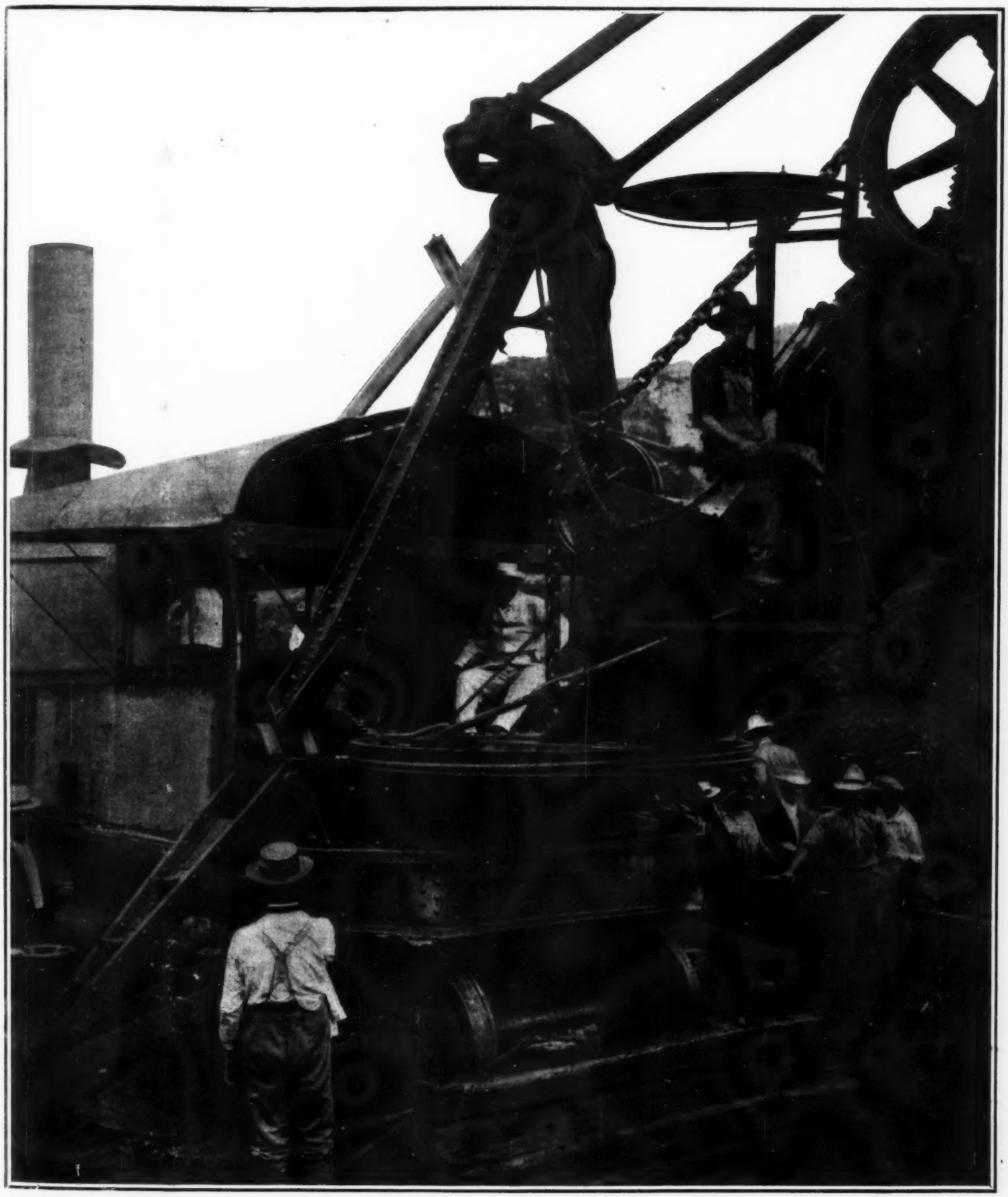
Scientific American, established 1845.
Scientific American Supplement, Vol. LXII., No. 1614. NEW YORK, DECEMBER 8, 1906. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



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PRESIDENT ROOSEVELT RUNNING A STEAM SHOVEL IN THE CULEBRA CUT AT PANAMA.

THE PRESIDENT AT PANAMA.

THE recent visit of the President to the Isthmus of Panama was both timely and stimulating. It occurred at a distinctly critical period in the affairs of the canal. Sweeping charges were being made, both in the methods of construction and the system of administration of the canal, the construction being about to pass into the hands of the contractors, and the administration being simplified, placed under one-man control and located definitely and permanently at the Isthmus. To this new departure the visit of President Roosevelt lends special significance. Although Mr. Roosevelt spent but a few days on the Isthmus, the time was busily employed; and, apart from the encouragement which was afforded to the employees by the presence of the Chief Executive in person, the President himself has undoubtedly acquired a firmer grasp upon the situation, and will find his personal observations of great value in arriving at future decisions on the many difficult points which must arise during the actual work of construction.

The present occasion marks the close of the second and the opening of the third chapter in the history of the Panama enterprise. The first chapter included the long and exhaustive examination of the physical conditions of the Isthmus, with a view to determining the best location for a canal, and resolved itself mainly into the determination of the relative merits of Nicaragua and Panama. That work in itself was of great magnitude, and involved the creation of various commissions and boards, and the putting through of costly surveys by large engineering forces. The subsequent decision in favor of Panama was followed by negotiations for the purchase of the rights and properties of the French company, and the securing of the necessary concessions from the Colombian government. Out of the negotiations and seemingly inevitable intrigues that followed, sprang the young republic of Panama, friendly to the United States and anxious to do everything that lay in its power to further, in the way of concessions and agreements, the prosecution of the work.

The second chapter contains the story of the vast work of preparation which was necessary before the actual work of excavation could be put into full swing. The strip of the canal zone, ten miles in width, stretching from ocean to ocean, was found to be a veritable breeding place of disease; unsanitary, ill provided with pure drinking water, and because of the prevalence of yellow fever and malaria, fatal to the health of the many thousands of laborers who would have to be crowded upon the work, if it were to be finished on time. During this second period an efficient sanitary corps was formed, and under its systematic methods the canal zone has been cleaned up, yellow fever practically eradicated, and malaria so far brought under control that the zone is now pronounced by engineers of high standing, who have been engaged for a year or more upon the work, to be no more threatening to health than many of our Southern States. Concurrently with the sanitation of the Isthmus, the great problem of housing and feeding the canal employees has been successfully solved, and comfortable quarters and good board are now obtainable at reasonable rates.

Another question, equally vital to the success of the enterprise, is that of administration. There is no denying that, here, many mistakes have been made, and that the earlier operations were hampered by a system that was altogether too cumbersome and slow to suit the very special conditions that are to be found at the Isthmus. The resignation of the then chief engineer, Mr. Wallace, served to emphasize the fact that, if the best results were to be secured, and the whole of the complicated organization were to work together harmoniously, the control of it must be placed in the hands of one man, who should be permanently located at the Isthmus, and who should have absolute authority in all matters pertaining to the construction of the canal.

One of the most happy results of the President's visit has been the signing of an executive order concentrating the authority in the canal construction in one man, and giving him supreme jurisdiction over the heads of the seven departments of the administration. Both the chairman and the department heads will have their residence at the Isthmus, and will be in a position to push the work through without, as before, having to make continual references to higher authority located at Washington, many thousand miles away. The Isthmian Canal Commission, which we understand is also to be reorganized, will make quarterly trips to the Isthmus for the purpose of receiving reports and advising with the chairman and the heads of departments.

The third and longest chapter in the history of the canal opens with the wise decision of the government to undertake the huge task of active construction by contract, and not by day labor supervised by the government engineers. The SCIENTIFIC AMERICAN has always urged that this was the only practical way in which this work could be done. Some time may be consumed before the government and the contractors can decide upon that final form of contract and those questions of price and time which are mutually agreeable. But once this has been determined, we believe that the canal will be put through steadily to a final completion. Enough has been learned, however, from the preliminary work, to make it certain that Congress must be prepared for the exercise of great liberality and patience; for the work will undoubtedly cost much more, and take longer by several years to complete, than was originally estimated.

FEED-WATER PURIFICATION.*

By R. T. STROHM.

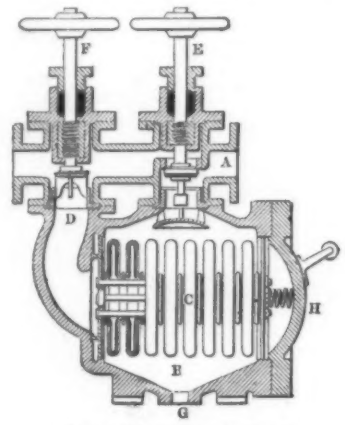
THE production of steam from water as carried on in the ordinary steam boiler is nothing more or less than the first step in a process of distillation. If the steam produced is quite dry and free from moisture of any kind as it leaves the boiler it will reduce to pure water when condensed, and this condensation if re-evaporated will leave no visible residue.

Now, if absolutely pure water were furnished to a steam boiler the evaporation of that water could be carried on for an indefinite period without the collection of extraneous matter inside the boiler. This would be the ideal condition of operation. However, it is never realized in practice, for the reason that absolutely pure feed-water is altogether too expensive to be obtained, and also because the water is far from being pure in most cases.

Boiler feed-water may be drawn from streams, from lakes, or from wells. In any case, the water has either flowed along the surfaces of the earth or has filtered through various depths of the surface strata. Pure water possesses the property of absorbing the materials with which it comes in contact. Consequently, as the rain passes over the ground or sinks into the earth it dissolves many substances. These vary in amount according to their solubility. Besides these, water may pick up and hold in suspension matter that is not soluble, as, for example, sand, clay, and organic substances.

Water of this kind, therefore, when fed to a boiler and evaporated, leaves behind it all of the impurities which it has absorbed or entrained, and the result is that these impurities accumulate and hinder the proper action of the boiler.

The hindrance to proper working of the boiler may manifest itself in several ways. If the impurities are such that they bake into a hard crust on the shell, the passage of heat from the furnace to the water will be retarded and the evaporative capacity of the boiler will be lowered. If the impurities are light, so that they float on the surface of the water, they are liable to cause foaming, which is undesirable. If the impurities consist of acids, the plates, tubes, and fittings will be eaten away, rendering them weak and unsafe. If the impurities collect in heavy deposits, as sludge, the transmission of heat will be rendered less rapid and there will be great danger of overheating the plates or tubes.



FEED-WATER FILTER.

In view of these facts, then, it becomes extremely desirable to remove from boiler feed-water as much of its foreign matter as can economically be separated from it, and to change into harmless forms such impurities as cannot be removed directly. Such treatment of feed-water is commonly termed feed-water purification, and because of its importance it has grown to be an industry of no mean proportions. Briefly, there are three reasons for purifying feed-water:

(1) To prevent loss of fuel, by having clean surface and rapid heat transmission.

(2) To avoid, as far as possible, the danger of boiler accidents.

(3) To reduce the cost of repairs.

There are four distinct methods of purification which may be used separately or in combination. They are:

(1) By settling, or sedimentation.

(2) By straining, or filtration.

(3) By heating, or thermal action.

(4) By chemical action, such as precipitation or neutralization.

The sedimentation process is of very limited application. All that it can do is to remove silt or sand which has been entrained with the water, and in order to do this effectively the water must be run into settling tanks and allowed to remain motionless until the mud sinks to the bottom by its own weight. Obviously, if a power station were of considerable importance, the size of tanks required to permit the proper settling of impurities would be so large as to prohibit the use of this method. For the settling process is slow, and cannot be hastened.

If mud, sand, and organic matter are contained in the feed-water and must be removed rapidly so as to permit continuous feeding of large quantities of water to the boilers, filtration should be adopted. There are a number of ways in which a filter may be constructed. For example, a wooden tank with a perforated false bottom may be used. On the false bottom are placed charcoal, coke, gravel, pebbles, or hay, or combinations of these materials. The water, flowing in at the top, passes downward through the filtering materials, being thus purified, and is then withdrawn by pump from a chamber beneath the false bottom and fed to the boilers.

The weight of the water is the force which causes the action of the coke and gravel filters, and the rate of filtration is therefore liable to be slow. If the water is put through a filter under pressure a more rapid action may be secured. The figure shows a cloth filter in which the water is under pressure during filtration. The feed-water is admitted at *A*, from the feed pump, and flows downward into the filtering chamber, *B*, which contains the filter, *C*. This filter is composed of a light bronze framework over which is drawn a bag of the cloth known as Turkish toweling. This bag is then drawn down between the several sections of the framework and tied with cords, as shown, thus exposing a large area of filtering surface. The sections are held together by four long bolts.

The inside of the filter, *C*, forms a hollow chamber communicating with the outlet pipe, *D*, which leads to the boiler. Therefore, the water must pass from the filtering chamber, *B*, through the filter cloth, *C*, and thence out at *D*, leaving all mud, oil or other foreign matter on the filter. This eventually hinders the action of the filter. A pressure gage is attached to the filter chamber and another communicates with the outlet side of the filter. When the difference between the readings of the two gages amounts to about three pounds, the filter requires cleaning. This may be done by closing the valves, *E* and *F*, and opening the drain, *G*. If the valve, *E*, is then opened slightly, the current of water from *A* through the chamber, *B*, to the drain, *G*, will loosen much of the accumulated sludge from the filter. If the valve, *E*, is then closed, and *F* opened, the water will flow through the cloth in a reverse direction, and out at *G*, carrying the dirt with it. If this method fails to clean the apparatus properly, the cover plate, *H*, must be removed and a new filter cloth put in. While this is being done, the valves, *E* and *F*, may be closed, and the water fed directly to the boiler. It would be better, however, to have more than one filter, so that each could be shut down for cleaning, at intervals, without interfering wholly with the filtering.

In many plants that are run condensing, the condensed steam is led to a hot well and from there returned to the boiler as feed-water. In its passage through the engine, the steam picks up a considerable amount of oil which it carries along with it. In spite of oil separators some of this oil is liable to find its way to the hot well, and thus to the feed pump. If, however, a filter of the type shown is used, the entrained oil may be completely removed.

The most troublesome of the scale-forming impurities found in ordinary boiler feed-water are the carbonates and sulphates of lime and magnesia. These, however, may be treated by the heating process, so that the feed-water may pass to the boiler fairly well purified; for the impurities mentioned are held in solution in the cold water, but if the water is heated it can no longer retain the impurities, and they appear in solid form, this being known as precipitation.

The carbonates are held in solution because the water contains carbonic acid. If the water is heated to the boiling point, or above, the carbonic acid is broken up and driven off as a gas, and the result is that the carbonates are precipitated, since the agent that has held them in solution in the water is destroyed. Since 212 deg. F. is the temperature of steam at atmospheric pressure, it is evident that the exhaust steam from engines can be used to furnish the heat for precipitating the carbonates.

If sulphates are present, however, the heating must be carried on at a much higher temperature to secure purification. The sulphates are soluble in water up to about 290 deg. F., so that, to precipitate them, it is necessary to heat the water to approximately 300 deg. F. This means that live steam of a pressure of 45 pounds or over must be used.

The carbonates, of themselves, do not really form a scale, but rather a fluffy deposit which alone may easily be washed and scraped loose. Unfortunately, however, other impurities, such as oil, organic matter, and mud are liable to get into the boiler, and the mixing of the carbonates with these materials results in the formation of a heavy sludge which will settle upon the tubes and sheets and soon harden under the action of the heat from the fire. The sulphates, on the other hand, are dreaded even by themselves, since they form hard, clinging scale which is most difficult to remove.

The fourth method of purification, that by the use of chemicals, is very largely used at the present time. It consists of adding certain chemicals to the feed-water so as to change the nature of the impurities from a harmful to a less harmful or harmless condition. This chemical purification may take place either before or after the water is fed to the boiler. The latter is the more common, for the reason that the boiler is thus used as the vessel in which the reactions may occur. When purification is carried on before feeding the water to the boiler, tanks must be built for the special purpose of treating the water.

The way in which impure water is rendered suitable for boiler feed-water may best be illustrated by examples. As already stated, the sulphate of lime forms a very hard scale. If, however, carbonate of

* Electrical World.

soda is introduced into the water, the sulphate of lime is changed to carbonate of lime, which settles in a fluffy form, while the carbonate of soda becomes sulphate of soda, which remains dissolved in the water and has no harmful action upon the boiler.

If the water contains both sulphate of lime and carbonate of lime, caustic soda may be used to advantage. The first action that takes place is the precipitation of the carbonate of lime, with the formation of carbonate of soda, and the carbonate of soda acts upon the sulphate of lime, breaking it up as already explained. In case the carbonates and sulphates of magnesia are present in the feed-water, the same general methods are followed.

It must be distinctly borne in mind, however, that chemical purification does not destroy the impurities. It simply converts them into other forms which will not act injuriously on the boiler. Consequently, if the chemical action takes place after the water is fed to the boiler, the precipitated materials will collect on the sheets and tubes and must be washed out at regular intervals.

There is yet another class of impurities which may be found in boiler feed-water and which, when present, is the cause of serious trouble. The class referred to is corrosives, or those impurities which attack the metal parts of the boiler and eat them away. Such action is due to the presence of free acids in the feed-water, the common ones being sulphuric and tannic acids, though others may occur. For example, if water containing magnesium chloride is introduced into a boiler and heated, muriatic acid is liberated, and this free acid has a very rapid corrosive effect on the boiler. To counteract corrosion, alkalies should be added, which will neutralize the acids present.

ALCOHOL ILLUMINATION.

By DR. P. WITTELSHOFER, Berlin.

IN all methods of illumination where the fuel is consumed merely in the presence of a draft of air, finely divided particles of carbon become separated and are not immediately oxidized. These being heated to incandescence produce the lighting quality of the flame. All the early methods of lighting depended upon the production of this incandescent or glowing flame, familiar examples being found in the candle, the kerosene lamp, and the ordinary gas jet.

An entirely new principle of illumination was introduced by the invention of the Welsbach incandescent gas light, usually known as the Welsbach lamp. In this a flame is supplied with a sufficient amount of air to produce complete combustion of the gases and there is, therefore, developed an intense degree of heat. Into the hottest zone, that is, in the outer portion of such a flame, is brought a finely divided refractory mineral substance, which becomes incandescent and transforms a part of the heat of the flame into a glowing white light. The burner used for laboratory purposes under the name of the Bunsen burner has served as a basis for the design of the peculiar burner adapted for this light. Auer von Welsbach, a chemist of Vienna, discovered the incandescent qualities of the so-called rare earths (cerium, thorium, erbium, yttrium, and zircon) and made them applicable in the technical industries. He studied the chemical peculiarities of these substances as well as the manner in which they could be used, and from these studies he devised the so-called mantle, a delicate web-like sleeve which surrounds the hot portion of the flame.

The great progress made possible by the introduction of the incandescent gas light depends upon the fact that since with a relatively small amount of fuel an intense light can be produced, the cost for the same amount of light is much less than formerly. Also with the invention of the Welsbach light it became possible to make use of those fuels which, when burning, do not give out much light, but produce a considerable amount of heat. Hence it was practicable to use alcohol as an illuminant, something impossible before, owing to the fact that it burns with a pale blue lusterless flame. The first alcohol incandescent lamps were devised in 1895, and attracted much attention by their brilliancy as compared with a similar gas light.

Through the efforts of inventors and manufacturers, several types of alcohol lamp have been put on the market, which because of their uniformity of operation and the excellence of their light give assurance that they will be able to compete satisfactorily with other lighting systems.

The chief difference between the alcohol incandescent lamp and those other systems which use liquid fuels, e.g., petroleum, or which use a gaseous product directly as illuminating gas, lies in the fact that in all the lamps using alcohol it must first be transformed into a gaseous condition. The vaporizing apparatus forms, therefore, an important part of the lamp.

In the construction of these lamps three types can be distinguished. The first class embraces lamps in which there is a small auxiliary flame of alcohol constantly burning, which heats and vaporizes alcohol drawn up through a tube leading from the basin of the lamp by the capillary action of a wick. After being vaporized, the alcohol passes through a small pressure-regulating valve into the peculiar burner, which is practically the same as used on the illuminating gas incandescent lamps.

In the second class there is a small auxiliary flame as in the other case, but it is controlled by suitable means, so that it may be turned down after the lamp is in operation. The alcohol to be consumed in the main burner is drawn up by a wick as in the former case, and passes through a heating portion where it is vaporized. The necessary heat in starting is provided by the auxiliary flame; after the main burner is in operation, the heat from this aids in the vaporization. In this case considerable vaporization occurs in the wick itself.

In the preceding systems the general arrangement is such that the fuel basin is placed beneath the burner, the fuel for the burner being elevated and conveyed to the vaporizer by the capillary action of the wick.

Those of the third class are applicable only as hanging lamps, and are used for the illumination of large halls and out-of-door locations. In this type both the fuel basin and the vaporizer are above the flame, so that the liquid to be vaporized is not conveyed to the vaporizer by capillarity but by hydrostatic pressure. With this form of lamp, since the flame is beneath the vaporizer, the former furnishes the necessary heat, and automatically provides itself with the necessary amount of vapor after the operation is once started. This last type of lamp has recently been highly developed, so that it may now produce as much light as the most powerful gas light and about as much as the average electric arc lamp.

It is possible to manufacture powerful lighting apparatus of this character which operates reliably and with a low fuel consumption up to 250 candle-power and over. For lighthouse purposes such lamps have been constructed of over 1,000 candle-power, these however having the fuel supplied under artificial pressure.

In the type of lamp previously described it is often found an inconvenience to wait the one to one and one-half minutes during which the vaporizer is being heated and during which time but feeble light is produced. Inventors have therefore sought to devise a lamp similar in operation to the kerosene lamp, which gives a light as soon as the match is applied. The principle of this lamp rests chiefly in directing air currents at the upper edge of the wick in such a way that the flame will take the form most suitable for the use of a mantle, at the same time providing sufficient air both within and without the flame to promote proper combustion or give the flame the amount of oxygen necessary to produce the most intense heat. The difficulties in the manufacture of a lamp which shall be satisfactory in all these respects cannot be overestimated. It is gratifying, however, to observe how many inventors who have busied themselves with the problem have constructed lamps which have been satisfactory when carefully operated. It must not be forgotten, however, that these lamps have a higher fuel consumption than the former types.

In view of the competition which exists to-day between the different lighting systems, a decision as to which should be chosen for any given conditions ought to depend largely upon the cost of the light produced. This in turn depends upon the amount of fuel required to produce a given amount of light. The strength of a light is measured in light units. The unit in use in Germany to-day is the Hefner candle-power, which is somewhat less than the light produced by the standard paraffin candle. While the flame of a good kerosene table lamp produces about 24 Hefner candle-power and consumes hourly 75 grammes or 1-10 liter (0.176 pint) of kerosene, an alcohol lamp giving the same light uses hourly only 50 grammes (0.088 pint) alcohol, corresponding to 60 cubic centimeters (3.6 inches). Hence, on the basis of fuel used alcohol produces an equivalent lighting effect with 6 to 10 cubic centimeters less fuel per hour. If kerosene sells at 20 pf. (5 cents) per liter and alcohol at 25 pf. (6¼ cents) a light of 25 candle-power will cost 2 pf. (½ cent) per hour with petroleum and 1.5 pf. (0.375 cent) with alcohol. Alcohol lighting is therefore one-fourth cheaper than petroleum. A considerable advantage in the favor of alcohol lies in the fact that it is possible to produce an exceedingly strong light without increasing the consumption of fuel per light unit. It follows therefore that in the course of time alcohol lamps will be devised whose fuel consumption will be even less than in the example given. There are, of course, also high-powered kerosene lamps. These have, however, the great disadvantages arising from excessive fuel consumption, and consequently usually develop an undesirable amount of heat.

Alcohol lamps are found on the market in sizes from 20 to 70 Hefner candle-power, corresponding to the lighting requirements of both industrial and household purposes. These vary in their fuel requirements per 10 candle-power between 15 and 30 cubic centimeters per hour. Hence, at the usual price in small quantities of 25 pf. (6¼ cents) per liter (1.76 pint), the production of light per 10 candle-power would be between 0.37 (0.0925 cent) and 0.60 pf. (0.15 cent) per hour. In the case of very large lamps, as previously mentioned, the fuel consumption per 10 candle-power diminishes to 12 cubic centimeters (0.72 cubic inch) per hour, so that the cost is only 0.30 pf. (0.075 cent) per hour.

From the preceding it would seem that the alcohol lamp is destined to come into sharp competition with the kerosene lamp, but it is equally certain that it will take its place among other lighting systems. With respect to cost it is exceeded in economy by the incandescent gas light alone, it being cheaper than the electric incandescent lamp. Under many circumstances it is, however, preferable to the gas light, since it can be made in portable form, independent of fixed location, and can be used in any place desired without special adjustment. Transportability is the chief reason why petroleum lamps are still used in many places where the use of gas would be much cheaper. The need of a lamp which can be carried about is felt principally in small households, hence in spite of the cheapness of gas, kerosene lamps maintain the supremacy for such uses. Take as an example the city of Berlin, where in the year 1900, out of 170,057 dwellings, only 76,479, or about one-sixth, used illuminating gas, there being 393,578 households in which the kerosene lamp was used entirely. As contrasted with the kerosene lamp, the alcohol lamp presents the possibility of increasing and cheapening the production of light, while at the same time creating less heat and emitting no disagreeable odor. Alcohol and kerosene, because of the difference in their chemical composition, differ materially in heating value. One kilogramme (2.2 pounds) of the former of 90 per cent purity releases during the process of combustion 5,500 heat units (calories) while the same quantity of petroleum completely burned gives off 10,000. It is seen, therefore, that alcohol has a heating value about half that of petroleum. In the combustion of these fuels for lighting purposes, there is of course a certain portion of the heat energy which is converted into light. In the case of the alcohol incandescent lamp, a much larger amount of heat is so transformed than is the case with the kerosene lamp. But even in the best alcohol lamps the heat changed into light is a very small percentage—only about 1 per cent—consequently in computations it introduces but very small errors to assume that all the heat corresponding to the volume of the fuel is given to the air of the room in which the lamp is operating. Calculation shows that an ordinary alcohol lamp of 25 candle-power would give to the room 288 heat units per hour, while a kerosene lamp of equal lighting effect would give out 750 calories. A large alcohol lamp of 50 candle-power heats up the air by 576 calories per hour; the same powered kerosene lamp gives out 1,500. It is seen, therefore, that the alcohol lamp gives off about one-third of the heat given off by the kerosene lamp, and this is a very decided advantage for alcohol.

Not less important than the smaller amount of heat developed is the lessened air pollution attendant upon the use of the alcohol lamp. Both alcohol and kerosene contain carbon, and in the combustion of both, carbon dioxide and water vapor are formed. The baneful effects of carbonic acid gas in the air of closed rooms are well known, and all rules of hygiene demand that in order to have as pure an air supply as possible, the amount of carbonic acid gas be reduced to the lowest possible amount. The chemical composition of kerosene shows that it contains 85 per cent of carbon, while in absolute alcohol there is only 52.2 per cent, and in 90 per cent alcohol but 44.6 per cent. It follows therefore that by the combustion of 100 grammes of 90 per cent alcohol only 163 grammes of carbon dioxide result as compared with 312 grammes of this gas resulting from the combustion of the same amount of petroleum.

If we consider the decidedly smaller amount of alcohol required to produce a given light-power as compared with petroleum, we find a still further advantage for alcohol from the standpoint of ventilation. An incandescent alcohol lamp of 25 candle-power produces 86 grammes of carbon dioxide per hour as compared with 234 per hour produced by a kerosene lamp of the same lighting effect. It is seen, therefore, that alcohol lighting has one-third the air-polluting effect of petroleum. This is borne out by the observed fact that the air in a room lighted by alcohol is usually in much better condition than when lighted by kerosene. We must add to these advantages the fact that the alcohol lamp is much more easily cared for and kept in condition, since there is no wick to trim or chimney to clean. In even the best kerosene lamps there is always a certain amount of soot and smoke, and leaking from the oil basin with its consequent odor and uncleanliness. These are absent in the case of the alcohol lamp. The general excellence of alcohol illumination is evidenced by the rapidity with which it is growing in favor, and in a few years its use will undoubtedly be widespread.

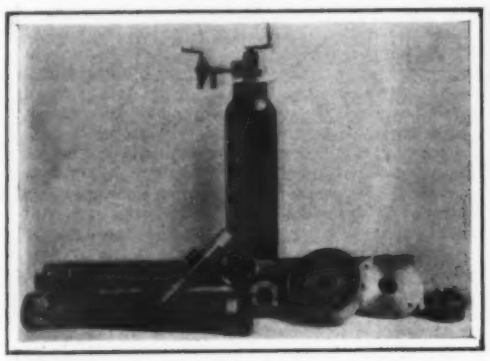
An unmistakable sign of progressive culture is the cry for "more light." In fulfillment of this wish, alcohol has entered not only into competition with kerosene, but with those haughty sisters gas and electricity. While the two latter, being capable of distribution from a central plant, are more strictly applicable for the lighting of large and medium-sized municipalities and industrial plants, alcohol illumination is particularly useful for small communities and isolated buildings and farmsteads, which desire to have a cheap and effective system of lighting. In railroad operations, in small cities and villages, and principally in agricultural districts, thousands of alcohol lamps are in constant use. To these must also be added the increasing number which are in use in private households in both the cities and the country.—Specially translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

There is one marked difference between machines and the men who operate them which should be noted. Machines, no matter how well they may be cared for, depreciate from five to ten per cent per year, owing to the advent of other and improved machines, while men, if they are properly cared for, may appreciate in value several hundred per cent in the same time. Yet as a general rule machines and tools are nurtured, fostered, and preserved long after their period of usefulness has expired, while the permanency of service of the men of the organization who operate them receives comparatively no consideration whatever. It cannot be expected that the men of an organization will show any spontaneous enthusiasm for interest in or loyalty to a management that openly displays so little interest in their welfare.

AN AUTOMATIC CARBONIC ACID GAS STARTER FOR AUTOMOBILE MOTORS.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

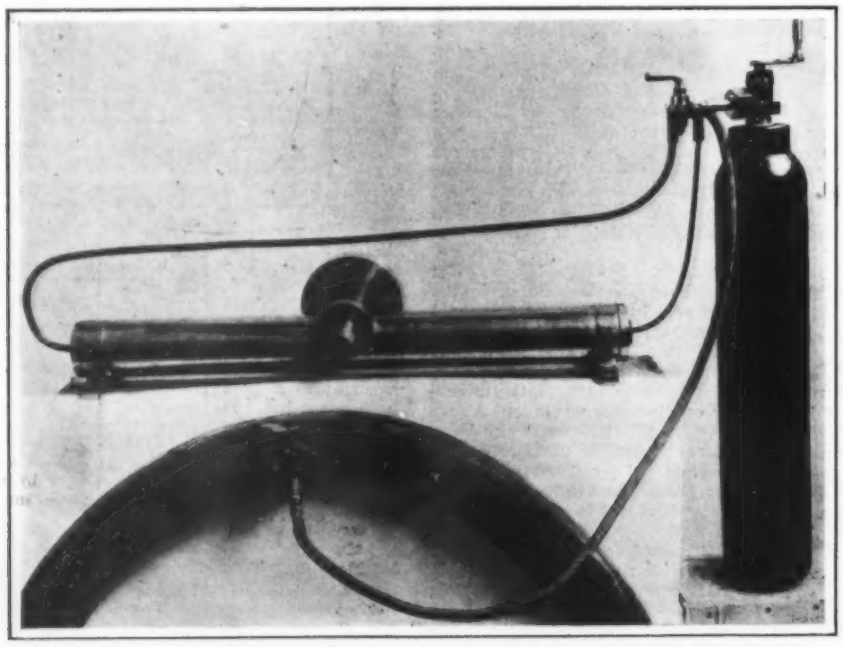
THE new apparatus known as the Cinogene, which has been recently brought out at Paris, is intended to supply a compact and practical device for starting the motor of an automobile without having to turn the starting crank which is connected with the motor as it is now necessary to do. Such an automatic device has been much needed, and will be greatly appreciated by chauffeurs, seeing that it is at best an inconvenient operation to start up the motor by means of the crank. The driver is obliged to dismount from the car, in the first place. Then the motor does not always start at once, and he is often obliged to do considerable cranking. This is especially the case where we have the more recent ignition system consisting of make-and-break igniters and magneto. With this arrangement, the motor must be turned rapidly in order to start it, and this brings out the great disadvantages of using a crank. Such a method is not in the line of modern progress, and we have already seen different inventions brought out from time to time which will allow the driver to use a handle or lever conveniently placed for the purpose of starting the motor. But all these inventions have been based upon the principle of storing up some of the energy developed by the motor itself and then setting this energy free to act upon the motor in starting. Such devices require, however, a considerable amount of complication from a mechanical standpoint in order to secure this result in a good manner. Besides, the source of energy did not always yield a constant output. In order to overcome these drawbacks and to make a simple and reliable device, the inventor of the present apparatus wished to solve the problem by deriving the energy from a source which lay outside of the motor. He claims to have done this in the device which we illustrate here. The energy for starting the motor is furnished by the expansion of liquid carbonic acid, which is contained in a steel bottle at a pressure of 800 pounds per square inch. A valve placed at the top of the bottle and within the driver's reach, gives vent to the carbonic acid gas. The latter escapes from the bottle and passes through a tube to the cylinder of the apparatus, which is placed horizontally. In the cylinder is a piston which works back and forth, carrying a rack in the middle part. The rack engages with a pinion which is mounted upon the end of the motor shaft. Before the start, the piston is on the right and at the end of the stroke. Introducing the gas pressure into the cylinder causes a strong push upon the piston. It moves quickly to the left, and the rack is thus made to revolve the pinion rapidly and with great force. The few revolutions thus obtained are sufficient to start the motor, and the action is much more rapid and certain than with the use of the usual starting crank. When the piston reaches the left at the end of its stroke, a valve opens on the cylinder and allows the gas to escape. Then the piston and rack are brought back to the right-hand side by means of a coiled spring in the other end of the cylinder, which had been compressed by the forward movement of the piston. During the return stroke of the piston, the pinion runs loose upon the motor shaft. The motor, after thus starting, continues to run without having any further connection with the mechanism of the Cinogene. One of the engravings shows the details of the starting device, by which its action is made clear. A carbonic acid bottle of ordinary size, such as can



PARTS OF THE CARBONIC ACID EQUIPMENT.

be obtained easily on the Continent in all the large cities at a cost of but $0.06 per pound, is enough for a hundred starting operations for a four-cylinder, 35-horse-power motor. The number of starts for a given motor depends upon its compression. A special form of bottle tested at 3,000 pounds per square inch and containing four pounds of carbonic acid, is supplied along with the apparatus. A special piping and set of valves is furnished separately, so that it can be filled directly, if need be, from larger cylinders of 20 or 40 pounds, such as are found in commerce.

One advantage of the Cinogene is that it can be fitted to the car without having to make any modifications. it is made in three sizes by the Isnard firm, of Grenoble, but the exterior form remains the same, and it is only the force which is variable. One of the views shows the device mounted on the front of a car. It takes up but little room, and, when desired, the ordinary crank can still be used to start the motor. The rubber tires of the car can also be inflated by the gas, which is very convenient and saves labor in pumping. An extra valve and hose is all that is needed for tire inflation. Before concluding we must note one special point in favor of the Cinogene, viz., that the start of the motor is always an assured fact, and can be carried out from 60 to 300 times in succession. On the contrary, in a device where the energy of the motor is stored up and then serves to supply the power, should there be a false start, all the energy is lost, and this makes the device useless.



INFLATING RUBBER TIRES WITH THE CARBONIC ACID EQUIPMENT.

THE PREVENTION OF ENGINE WRECKS FROM CYLINDER WATER.

MANY serious accidents to engines are caused by water finding its way into the cylinder from the steam pipe when the latter is not properly drained, and even from the boilers themselves when these, for any reason, throw it off in the process of priming. Water is also drawn back into the cylinder in the case of condensing engines through failure of the condensing apparatus. These accidents do not occur without good reason, for when the plant is in operation and all its parts are in proper condition, the chance of trouble from this cause is extremely remote. It is the vigilance of the engine-driver and fireman upon which dependence must be placed for the prevention of injury. Instances of this sort have been often mentioned where engines have been broken down as a result of the introduction of water into the cylinder, and, as everyone who has had experience in the matter knows, the effect is liable to be disastrous. It is not merely a few bolts which break or some minor part which becomes deranged, but some vital piece in the structure is the thing which usually gives way, involving the stoppage of the engine and the work which it drives for days or weeks at a time, until the necessary repairs can be effected.

It seems a pity that accidents which from one cause or another are so liable to occur, and which are attended with such important consequences, cannot in some way be made less disastrous. With so much at stake, designers of engines might bring about some system which should lessen, if not wholly overcome, the evil results following the introduction of water into the cylinder. The engineer maintains that he cannot supply in his design the brains and vigilance which the engine-driver lacks. He claims that it is one of the exigencies attending the generation of power that a charge of water may get into the cylinder, and when that happens the only thing to do is to accept the consequences, however serious they may be. This, however, is not what the power-plant purchaser requires from engineering. He states the conditions, and what he desires of the engineer is that the iron and brass shall be so put together that the conditions will be met, one of the most important of which is that his plant shall be kept running and turning out regularly the allotted quantity of production.

Considerable improvement has been made of late years, it is true, with a view to providing against injuries of this kind. Cylinders are fitted with relief valves, set at a point slightly above the highest working pressure, and made of considerable size, so as to provide a means for the escape of water if it should accumulate in excessive quantity. They are applied to the sides of the cylinder, one at each end, and with this location it will be seen that they can be made of only limited size. Experience has shown that this plan does not secure a sufficient opening to discharge the large volume which must be taken care of if the water comes over at all.

In the case of single-acting engines, the injury produced by accidental accumulations of water can be greatly lessened by making the cylinder head of such form that when a dangerous pressure is brought to bear upon it, the breaking strength is exceeded, and the central portion of the plate gives way, and allows the water to discharge through an opening, nearly, if not quite, the full size of the bore of the cylinder. Such an arrangement is impracticable on the ordinary double-acting engine, owing to the attachment of the framework of the engine to the opposite end of the cylinder. The same idea, however, might be carried out by providing a secondary cover of a diameter considerably less than that of the cylinder bore, the cover being designed so as to give way by breakage when a dangerous pressure is reached and thus provide a relief opening of much greater size than could be had by the common practice. There may be other methods of accomplishing the same end, but it must be admitted that some better means of meeting emergencies in the running of engines due to water in the cylinder should be provided. There is something incongruous in designing some detail of a cylinder so weak as to invite breakage when the pressure reaches a certain limit, but if this serves as a safety valve and prevents the wrecking of the main structure, it is certainly a wise provision.—From The Engineering Record.

THE STARTING DEVICE MOUNTED ON THE FRONT OF A CAR.

OBJECTIONS TO HIGH CRANE SPEEDS.

THERE is at the present time something of a demand for excessively high speeds, and the motives of the manufacturers who advise against them are sometimes misunderstood. It is not that the problem presents any difficulties from the manufacturer's standpoint. He may prefer to furnish a standard article, from considerations of cost and delivery, but oftener he is considering the direct benefit to the customer and the indirect benefit to himself. The manufacturer and user may recognize the same advantages and disadvantages, but from their different standpoints they do not see them in the same proportion.

The one advantage sought in high speeds is a saving of time, but this is often overestimated. Take, for example, a 10-ton crane with full load speed of 20 feet per minute. We may assume that the average load will not be more than one or two tons, that the average speed for such load will be 30 feet per minute, and that the average lift is 5 feet. Allowing fifty per cent more time for acceleration from a state of

rest, and we find the time for an average lift to be fifteen seconds.

If the speed of a hoist were doubled, it would at first appear that one-half of this time, or seven and one-half seconds, would be saved. If twenty lifts were made per hour, the result would be a saving of only about four per cent of the time. When it is remembered that many of the lifts must be very slow, regardless of what the crane is capable of doing, and that traverse movements are usually started as soon as the load is clear of surrounding objects and before the hoist movement is stopped, the actual saving is reduced to a very inconsiderable amount of time.

Where a large floor area is covered, a greater saving can be made by increasing speeds of horizontal movements, but the swaying of load which results from high speeds and sudden starting and stopping, sets a limit to the saving that can be made in this direction.

Two objections may be offered to excessively high speeds. First, the accidents that are likely to result from putting a high-speed crane in the hands of an incompetent operator often cause the loss of much more time than is saved by the higher speeds, and greatly increase the cost of repairs. Second, if the crane is not usually run at full speed, there is a constant loss of power in the rheostat, and unnecessary wear and tear on the controller parts, both of which cause expense and loss of time. The above comparisons apply with the most force to cranes in foundries, and with least force to cranes in mills where much higher speeds are necessary and practical.—Harry Sawyer, before the American Foundrymen's Association.

THE NEWMAN VARIABLE SPEED GEAR.*

By EMILE GUARINI.

THIS new gear, recently brought out by an English firm, is intended for application to motor cars, machine tools, textile machinery, electric motors, printing presses, papermaking machinery, hoisting machinery, electric cable-making machinery, and in numerous other cases which will occur to any engineer. In this gear, from a shaft driven at a constant speed by any source of power, a complete range of speeds varying from zero to full speed, by perfect gradual changes, can be obtained, the variation being made without the least difficulty and without any shock.

On the end of the constant-speed shaft a crank or eccentric of variable throw is fixed. The throw of this eccentric can be varied at will by suitable mechanism. Connected with the variable eccentric are four arms or connecting rods, which are joined at their outer ends to studs, each stud being fixed in clutches, which are of the roller type, i.e., they drive in only one direction, and release when turned in the opposite direction. Each clutch turns on a stud or pin which is fixed into the back of the casing surrounding the gearing. The clutches are surrounded by rings having gear teeth formed on them. These four gear rings all gear with one common pinion in the center, this pinion being fixed on the end of the variable speed shaft.

The variable eccentric is not directly connected in any way to the last-named pinion, the constant-speed shaft being supposed to stand out and there being a space between the eccentric and the pinion.

Now, if the eccentric is supposed to revolve, it will be understood that the clutches are moved backward and forward at each revolution of the eccentric through an angle depending on the throw of the eccentric. The greater the throw of the eccentric the greater will be the angle, while if the throw is reduced to zero, i.e., if the center of the eccentric is made to coincide with the center of the constant-speed shaft, the clutches will be at rest. As each clutch moves backward and forward it drives its gear ring through a certain distance and then releases, but it must be observed that before it has released, the next clutch has taken up the driving, and that therefore the motion of the pinion and variable-speed shaft is continuous, and its speed depends on the angle through which the clutch oscillates, this angle being controlled by the throw of the eccentric. With zero throw the variable-speed shaft is at rest, but begins to move as soon as the eccentric is given a slight throw, and attains a maximum speed with the maximum throw of the eccentric.

Different methods are used for varying and controlling the throw of the crank or eccentric, depending on the purpose for which the gearing is intended to be used. It is sometimes assumed by people who have not seen this gear at work that the motion cannot be even, but that this is an entire misconception is proved by the smooth running of the mechanism at speeds of over 1,000 revolutions per minute.

It is perhaps natural to conclude at first sight that the efficiency of this mechanism must be low, i.e., that a considerable amount of power must be lost in internal friction. Experience proves, however, that this is entirely a misconception. If the mechanism is considered in any given position it will be found that one clutch is driving and the other three are over-running, or free-wheeling, i.e., the power is being transmitted from the variable crank or eccentric, through the connecting rod, to the stud on the clutch, which is driving the gear wheel, which in its turn drives the pinion. The clutch is, in this case, locked with the gear ring, and therefore there is no power lost in the clutch itself, and in fact the clutch may practically be left out of consideration and the stud assumed to be fixed to the gear wheel itself. If we consider the other three gear wheels and clutches, we find that they are all over-running or free-wheeling, and it is found from actual test that the power to over-run these clutches is very small indeed, as the four clutches of the largest gears can be all over-run together by hand with the greatest ease. It is also obvious that the power lost in over-running the clutches is a constant quantity, whatever the power transmitted through the gears which are driving may be, and it therefore becomes a very small proportion at full power.

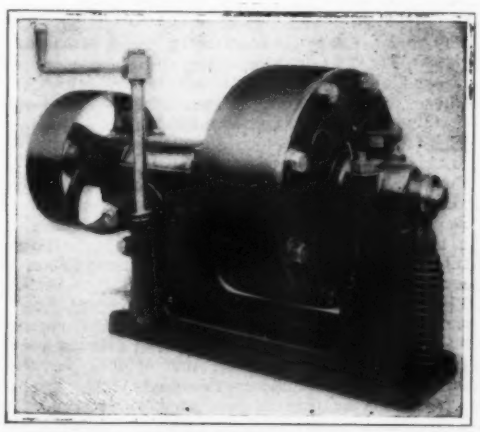
The power lost in releasing these clutches is said

THE SPEED GEAR DISSECTED.

to be inappreciable, there being no sticking whatever, and, in fact, the clutch releases automatically immediately the load is removed. It will therefore be seen that at any given moment, the power lost is that due to the friction of the crankpin or eccentric, the clutch stud, and the gears, the overrunning clutches and the three other clutch studs. As these latter are running light, i.e. with no load, the friction there is not appreciable. The loss of power with well-cut gear teeth is very small, and therefore the chief loss must occur between the crankpin and clutch stud, but will obviously not be large. It is stated that in actual tests which have been carried out results have been obtained giving over 90 per cent efficiency.

Another question which perhaps naturally arises in connection with this gear is "How will the roller clutches wear?" as they are used in this gear under somewhat novel conditions compared to the remainder of the mechanism. To illustrate the inappreciable wear that takes place in these clutches, the makers state that a motor car weighing, with passengers, about 1½ tons, has been driven between 1,000 and 2,000 miles by clutch rings which still have the tool marks left on the gripping surfaces. The unpleasant jarring and damage to the teeth, which often takes place in changing speeds with the usual type of gear, cannot occur in this arrangement, as the gear teeth are always in mesh.

As previously stated, the applications of this gear are very numerous. Among the most important is its application to motor cars. The two principal advantages of this gear in this connection are its complete range of speed and the perfect ease with which it can be manipulated. The large range of speed enables a higher average speed of the car to be maintained, as the motor can always be kept working at its full power if required. Another important advantage in this gear for motor cars is the fact that it is self-locking in one direction, and that therefore a car can be stopped on any hill without applying the brakes and without the slightest fear of its running backward.



VARIABLE SPEED GEAR ARRANGED AS A COUNTERSHAFT.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE MANUFACTURE OF SULPHURIC ACID BY THE CONTACT PROCESS.

THE manufacture of sulphuric acid, one of the most important industries, is now undergoing a profound modification, which consists not so much in an improvement in the process in use and in that of the present *modus operandi* as in a complete change, the result of the application of new theories.

The manufacture of sulphuric acid by the contact process or catalysis is based upon the principle of the direct oxidation of sulphurous acid by causing this gas, mixed with oxygen, to come into contact with a catalyzing substance, such as platinized asbestos, oxide of iron, quartz, etc. This principle, which is apparently very simple, is complicated by numerous difficulties when it comes to applying it industrially.

In spite of these difficulties, the necessity of dispensing with very costly processes of concentration led manufacturers to become interested in the contact method, the only one which could permit them to prepare sulphuric acid at once, as free from water as possible. For that reason, while many scientists and technologists who were still occupying themselves with the lead chamber process, brought all their efforts to bear on the improvement of concentrating apparatus (concentration in glass, platinum, lead, etc., according to the processes of Kessner, Zanner, Kuhlmann, etc.), others, on the contrary, strove to convert the contact process (which was then confined to the laboratory) into a commercial method.

Before directly entering upon the technical part of the question it seems to us of interest to cast a glance backward and embrace in a rapid retrospective examination the evolution of this new process. It was Sir Humphry Davy who in 1817 discovered the catalytic action of platinum, and who suggested to Peregrine Phillips, Jr., of Bristol, the idea of employing this metal for the direct combination of oxygen with sulphurous acid. The patent taken out by him in England in 1831 assured him the title of priority in the manufacture of sulphuric acid by the contact process.

In 1846 Jullion proposed platinized asbestos as a catalyzing material; in 1852 Woehler and Mahla detected the same catalyzing properties in the oxides of iron, copper, and chromium, and remarked besides that the formation of sulphuric anhydride was possible by employing dry sulphurous acid and oxygen; at the same epoch, Petrie discovered that quartz heated to 300 deg. C. likewise possessed the catalytic property; but it was Winkler who, putting to profit the experiments of Davy, Woehler, Mahla, Plattner, Reich, Petrie,

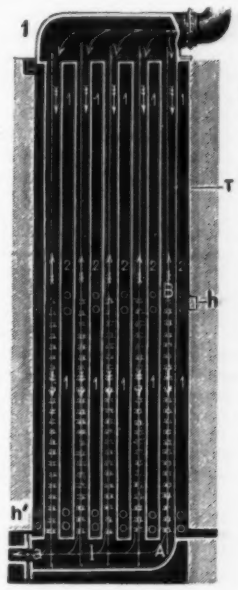


FIG. 1.

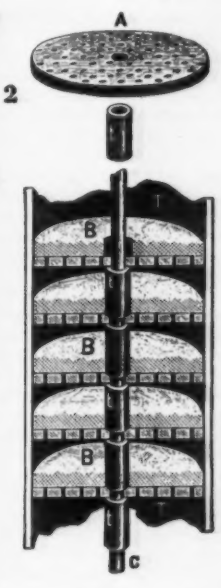


FIG. 2.

1. Section of a Badische catalyzer. T, catalyzing tubes open at both ends and filled from A to B with platinized asbestos. h, gas inlets by which the temperature can be regulated. I, lower part of the catalyzer in which the vapors of sulphuric anhydride accumulate. a, outlet of the vapor toward the absorption apparatus. 2. A, disk of perforated wire plate. T T, catalyzing tube. C, central rod on which the disks and sections of pipe, *t t*, are strung. B, platinized asbestos.

etc., brought to a focus, at least theoretically, the industrial manufacture of sulphuric acid by the contact process. At present this process is, in the majority of works that are employing it, still in the experimental stage. Many manufacturers, by reason of the economic importance that may result from the least improvement, are keeping their process secret. In spite of this, the question has already been sufficiently studied, and the results obtained in certain cases have been satisfactory enough to allow us to make known to our readers, at least in its broad lines, this recent industry, which seems to realize the hopes expressed in 1835 by Clement Desormes, who said: "I am convinced that in ten years at the most we shall succeed in the industrial preparation of sulphuric acid by means of its constituents, without lead chambers and without having recourse either to nitric acid or to nitrates." The present manufacture of sulphuric acid by the contact process comprises three operations:

1. Preparation and purification of the sulphurous acid.
2. Combination of the sulphurous acid and oxygen in apparatus called catalyzers.
3. Absorption of the vapors of sulphuric anhydride formed.

I. Preparation and Purification of the Sulphurous Acid.—The sulphurous acid is generally prepared, as in the lead chamber process, by roasting pyrites in special furnaces, such as those of Maletra, Hasenderer and Helbig, Eichhorn and Liebig, etc. As there is nothing peculiar about this operation and as it has already been described in numerous treatises, we shall not speak of it. But an essential point is the purification to which the sulphurous acid designed for

catalysis must be submitted. This gas, at its exit from the pyrites furnaces, contains from 7 to 9 per cent of sulphurous acid (by volume) and a certain number of impurities, some of which are very prejudicial to the efficiency of the process. Arsenic, phosphorus, and mercury, even in the state of traces, may have a very bad influence. Arsenic in the proportion of 1 to 2 per cent with respect to the weight of the platinum contained in the contact mass may render the latter entirely inactive. Hydrochloric acid and chlorine lower the catalytic efficiency from 97 to 50 and even 40 per cent. Iron, antimony, and lead are infinitely less injurious. The sulphuric anhydride which forms during the calcination of the pyrites must also be eliminated.

The purification of the pyrites gases was, at the beginning, one of the principal obstacles that offered itself to the success of the process, and required on the part of manufacturers several years' labor and the sacrifice of much money to devise a method to effect it economically. Experiment demonstrated that the purification of sulphurous gas was possible and that all the impurities that accompanied it could be retained by cooling the gas and submitting it to an intimate and prolonged contact with sulphurous acid or simply with water. An important precaution, one long neglected, was the necessity of cooling the gas progressively. In fact, the white fumes of sulphuric anhydride that must be eliminated before the catalysis, condense with great difficulty if they are cooled abruptly. The same is true with the extremely light sulphur which is carried along with the gases when the pyrites are thoroughly calcined.

II. Combination of the Sulphurous Acid and Oxygen.—Catalyzers.—The mixture of gas, $SO_2 + O$, purified and dried, is then sent to the catalyzers. These apparatus, of which there are several types, consist of a bundle of T-iron tubes filled half full of the catalyzing substance, *A B*, which is generally platinized asbestos.* These tubes are in most cases arranged vertically in a cylinder in which debouch air inlets *h h'*, of which the temperature can be regulated and which serve to heat the catalyzing tubes (Fig. 1).

Two points are then to be examined: (1) The velocity of the gases to be catalyzed; and (2) the temperature of reaction. As shown in the accompanying diagram (Fig. 2), such velocity should be about 300 cubic centimeters per minute in a catalyzer heated to 400 deg. C. As the reaction $SO_2 + O = SO_3$ is strongly exothermic (22,600 heat units), it is not necessary to continue to heat the upper part of the catalyzing tubes after the reaction has begun, since it continues of itself. The following is the method of starting things. The apparatus (Fig. 1) is first heated by means of the hot air inlets *h* and *h'*. After the temperature of reaction has reached about 400 deg. C., the sulphurous gas, mixed with air, is made to enter the upper part of the catalyzer, and then a current of cold air is substituted for the current of hot air sent through *h'*. In this way the products of the reaction are cooled slowly and regularly. This is an important point, which may modify the rendering in sulphuric anhydride in a marked proportion.

We ought to say, by the way, that if the platinum is fouled by any sort of impurity it will be necessary at the beginning to raise the temperature of the catalyzer to 530 deg. C.

In order that the contact of the gases and asbestos may be as uniform as possible, the contact substance is arranged on perforated iron plate disks arranged on a rod and kept at an equal distance from each other by sections of pipe (Fig. 1).

III. Absorption of the Vapors of Sulphuric Anhydride Formed.—The sulphuric anhydride due to the reaction and which is disengaged by the lower part, *I*, of the catalyzer, is then absorbed by sulphuric acid. This problem of the absorption of the vapors of anhydride was a new difficulty that numerous experiments, tried methodically, permitted of solving.

By reason of the great affinity of sulphuric anhydride for water, it would have seemed, in fact, that the best method of fixing SO_3 was to introduce the products of the catalysis into water or an acid of slight concentration. Experience has proved the error of this reasoning by demonstrating that under such circumstances the gases making their exit were still charged with a very appreciable quantity of sulphuric anhydride condensable with difficulty. It was found that the best means of completely retaining the SO_3 was to collect it in concentrated sulphuric acid (97 to 98 per cent SO_4H_2). By keeping the concentration within such limits, by means of a permanent addition of water or dilute acid, we may obtain a continuous production of 99 per cent acid.

The apparatus in which the absorption is effected should be of wrought iron, which, in fact, resists the action of the "oil" (as the acid is called in commerce), while cast iron, easily attacked under such conditions, may give rise to serious accidents.

Here, then, we have a brief sketch of the evolution and present technology of an industry which, by reason of the ever-increasing demand that the manufacture of alizarine and other coloring matters creates for fuming sulphuric acid, is destined to replace all the expensive processes of concentration and successfully to compete with the lead-chamber process of manufacture employed up to the present.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the French of G. Loucheux in La Nature.

* To prepare this, asbestos is saturated with a solution of chloride of platinum. The whole is rendered alkaline with a little carbonate of soda and then heated in the presence of formiate of soda. When the reduction is finished the asbestos is washed and dried.

[Concluded from SUPPLEMENT No. 1613, page 25840.]

AIR IN RELATION TO THE SURFACE-CONDENSATION OF LOW-PRESSURE STEAM: AN EXPERIMENTAL STUDY OF CONDENSER PROBLEMS.*

By JAMES ALEX. SMITH.

EFFECT OF VARIATION OF RATE OF FLOW OF COOLING WATER.

THE effects of variation of mixtures and temperatures have been dealt with, it yet remains to consider variation of flow (mass-time dimensions). This cannot be dealt with mathematically, unless some one rate is known, and unless it is assumed that the rate of metallic transmission—and the corresponding factor for water—is either known or is constant. In the absence of this knowledge, the writer proceeded by experiment.

In each test the temperature and composition of the mixture were constant, for that test, while the rate of flow was varied by steps of 2½ pounds, from 2½ to 15 pounds per m. Fig. 7 illustrates two typical cases. The conditions were: Vapor temperature, 110 deg.; initial water temperature, 69.5 deg.; in curve (*A*) nearly pure steam, in curve (*B*) steam plus 0.22 inch (mercury gage) of air; one square foot of surface, as before. The dots are the observed points.

Discussion of Curves.—The air effect is here, as elsewhere, pronounced.

At very low velocities the flow is non-eddying, and passes through the tubes almost as a solid would, the cooling effect, exercised to a maximum at contact with the tube wall, reaching the axial portion of the mass chiefly by slow conduction. At higher temperatures the motion becomes sinuous or turbulous, inter-mixture is rapid, and the general effect is greater, not only by the greater mass dealt with, but also by the more effective contact of the component parts of that mass with the tube. Indented tubes, or those of irregular cross-section, accentuate the inter-mixture.

FIG. 7.—VARIATION OF THERMAL INCREMENTS, DUE TO VARIATION OF FLOW.

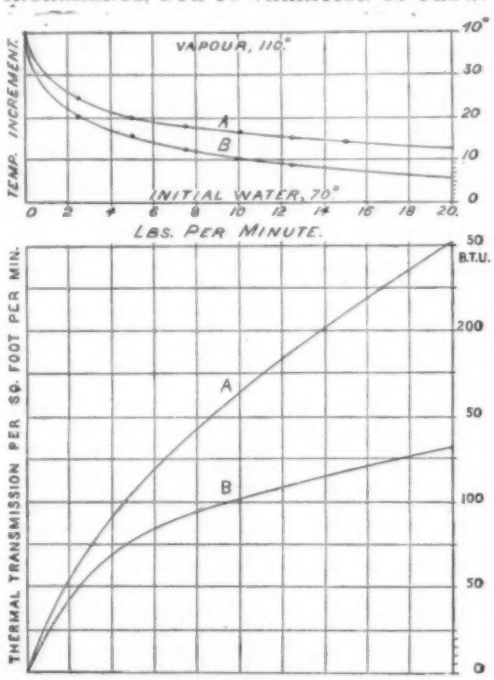


FIG. 8.—VARIATION OF B.T.U. TRANSMITTED, DUE TO VARIATION OF FLOW.

A, A. Steam with traces only of air; B, B. Curves show effect of 0.22 in. (mercury pressure at 70°) added air.

Note.—The inclination to the base of curve A, Fig. 8, increases rapidly when the water initial temperature is reduced.

The variation of rate of curvature in the lines (*A*) and (*B*), Fig. 7, is due, in part, to the variation of the internal motion of the flow.

The curves also show that the effect becomes considerably exhausted at quite moderate velocities.

The tendency, as the variable becomes inconsiderable, is toward the simple ratio.

Temperature (increment) varies inversely as flow multiplied by temperature difference.

Duty and Flow.—The work done is dependent upon the mass operated upon and the temperature increment of that mass. It is expressed as the product of mass into temperature.

Fig. 8 is thus derived from the data of Fig. 7. Curve (*A*) refers to pure steam, curve (*B*) to steam plus 0.22 inch (mercury gage, and at 70 deg.) of added air, in both cases at a temperature of 110 deg. The divisions of the base denote flow in pounds per minute, those of the perpendicular, B. T. U. per minute per square foot of surface for each total temperature increment (not per degree).

Discussion of Curves.—The air effect is so pronounced that it is scarcely necessary to direct attention to it.

Curve (*A*) indicates that the work done is not in direct ratio to the flow. The rate of increment of work is less than the rate of increment of flow, and the proportion is a decreasing one, as the subjoined table shows:

Curve (*A*).

Flow in lbs. per sq. ft. per m..	5	10	15
Ratio	1	2	3
Thermal units per sq. ft. per m.	100.00	164.000	210.00
Ratio	1.00	1.64	2.10
Ratio per unit of flow.....	1.00	.82	.70

Curve (*B*).

Flow in lbs. per sq. ft. per m..	5	10	15
Ratio	1	2	3
Thermal units per sq. ft. per m.	77.00	101.00	117.00
Ratio	1.00	1.31	1.52
Ratio per unit of flow.....	1.00	.65	.51

Apart from static and friction heads the energy required to produce flow varies as the product of the mass into the velocity squared.

Therefore, since the advantage resulting from increased flow is a diminishing one, and the cost of attaining it advances at a rapid rate, a point will be soon attained beyond which it is unwise to pass.

Once velocity has been imparted it, here, continues—apart from skin friction—indefinitely, therefore, a tube of indefinitely great length might be used were it not that it has already been shown that short tubes are relatively the more thermally efficient. The designer must compromise in each particular instance.

As a generalization, when the steam is nearly pure—as it must be in future practice—and when the cooling supply is large, and the static head small, short tubes will prove the most efficient.

When it is a case of using an existing condenser, then the mechanical equivalent of increased flow rises at a very rapid rate, i. e., as the third power of the velocity. This results from the preceding equation (power varies as velocity squared for unit mass), and the fact that, as a consequence of the constant sectional area of the tubes, the mass also varies as the velocity. For instance, doubling the flow requires that the power supplied shall be increased eightfold. When there are no means of checking the power abstracted for this end from an installation, it may well be that an increased vacuum is being very dearly bought.

REMOVAL OF GASES.

This ranks next in importance to prevention of entry, but the author has no intention of here adding to the discussion of pump design at present so prominent.

Unless the air is initially removed from the feed by spraying cold through a vacuum chamber, or spraying at boiling point through steam, the introduction of a certain volume of gas in the boiler feed is inevitable, but the amount, including mechanically entrained bubbles, should not exceed about 1/30 of the feed volume under ordinary atmospheric conditions. Then, if it is assumed that leakage is entirely absent, and that not more than 1/20 inch (mercury gage) partial pressure of air is to be permitted in the condenser, the ratio of effective volume of air pump to boiler feed is $1/30$ of $(30 \div 1/20) : 1 = 20 : 1$. This represents the *theoretic* minimum for the assumed conditions.

The work of the air pump is more onerous than when steam partial pressures equaled from four to six inches; then compressions of from 7½ to 5 times determined discharge into the atmosphere at 30 inches. Now the compression required may be thirtyfold or more, and any non-effective space becomes a serious consideration, sometimes met by compounding.

But compounding does not alter the initial volume of the steam containing the diffused gas, requiring to be dealt with. Subsidiary condensation will effect this end if the residual gases be swept from the main condenser by a steam jet, or other means, into a small condenser maintained at the lowest possible temperature. Then the deposition of a portion of the steam, as water, renders the mixture finally presented to the pump richer in air, and smaller in volume, therefore a smaller pump will suffice.

It is obvious that the air pump must in such case be differentiated from the water-removing pump. Entrained water as hot as, or hotter than, the main condenser, would altogether defeat the end sought.

The slowness of gaseous diffusion, compared with the velocity of vapor flow, will prevent the passage backward of the accumulated air from the smaller to the larger condenser, especially if the vapor circulation be forced. The theoretic limit of concentration is reached when the absolute pressure in both condensers is equal, and when that of air in each is the difference between the common pressure and the partial pressures severally due to steam at the respective temperatures.

Experimental Verification.—The condenser used in these experiments, one of about 1/30 its vapor capacity, and the mercury gage were connected in such manner that all could be in communication or each condenser with the gage to the exclusion of the other condenser. Both condensers were boiled clear from air, then air was added to the larger alone. When the temperature of the larger was constant at 110 deg. and the smaller was at 66 deg. they were for a short time placed in communication with each other, and with the gage, which showed an absolute pressure measured by 2.75 inches of mercury.

Separated, and tested individually, the readings were as follows:

* Read before the Victorian Institute of Engineers. Revised by the author.

LARGE CONDENSER.

2.750 absolute pressure in inches of mercury.
2.576 partial pressure due to steam at 110 deg.

.174 partial pressure of air at 110 deg.

SMALL CONDENSER.

2.750 absolute pressure in inches of mercury.
.639 partial pressure due to steam at 66 deg.

2.111 partial pressure of air at 66 deg.

The air had been concentrated in the ratio 2.111 : .174, and, under similar conditions, the effective capacity of a connected air pump would have been increased in like proportion. At 100 deg. and 90 deg. main condenser temperatures, equivalent concentration ensued.

Air Pump Inlets.—It is evident that these should be so multiplied in number, and so situated that the concentrating air in the vapor will pursue the course of shortest contact with the cooling surface not, as is too often the case, the longest. No dead spaces should be possible.

RATE OF APPROACH OF STEAM TO A CONDENSING SURFACE.

From a known volume of steam at any given temperature, and the rate of condensation per unit surface, this can readily be computed. With pure steam at 140 deg. and 10 pounds per m. flow, it is in round numbers, only about 2/3 of a foot per second. This points to the necessity, not only of exhaust pipes of large proportions—a point now well recognized—but also of ample inter-tube spaces and passages.

The molecular velocity consequent upon change of state upon condensation is not expressed by the preceding.

The effect of forced, or blast, impact, and the further effect due to the fact that one side of the tube would then be in "shadow," are subjects for further investigation.

It may be noted, parenthetically, that formulæ that express exhaust sectional area as a function of a constant force may be inaccurate. In all reciprocating engines, and some turbines, the acceleration is intermittent, and the area required proportionately greater.

TESTING CONDENSERS.

The method of gage, barometer, and thermometer needs no further explanation. The warnings may, however, be reiterated that barometers may differ from truth by tenths of an inch, thermometers by several whole degrees, and Bourdon gages by half inches, and that the presence of water at a temperature differing from that of the vapor will vitiate the readings in any case.

To obviate the latter source of error, vapor samples received into a boiled-out flask may be tested by gage, at the temperature of the condenser. Or the flask may be opened beneath mercury or water *hot* and thoroughly freed from air by boiling. Corrected for vapor tension the volume unoccupied by fluid determines the air present.

SECONDARY CONDENSER ACTION.

A point that appears to have escaped notice is the effect of the drip from horizontal tubes. It is analogous to jet condenser action.

At the refrigerating surface the fluid, especially if air be present, will be colder than the vapor, and if sufficient time, equivalent to length of fall, is allowed, this difference will be utilized in cooling the steam and heating the hot well water.

Land practice has largely followed marine, in which restricted space compels the close centering of the tubes. It remains to be seen whether inter-tube spaces and the flooding of lower tubes by the drip from the higher cannot be dealt with more efficiently in design.

Possibly the preceding may afford an explanation of the greater efficiency claimed for horizontal as compared with vertical tubes, from which drip does not occur. The experiments given in support of these claims do not, unfortunately, specify the air present, if any, and the omission is important.

EFFECT OF THICKNESS AND THERMAL CONDUCTIVITY OF THE WALLS, AND EFFECT OF TUBE DIAMETER,

are subjects worthy of full investigation, and must be determined before a complete theory of the condenser can be enunciated.

CLIMATE.

Passing notice will suffice, although the question is very important, especially in marine work, where the temperature of the cooling water supplied to the same condenser will frequently vary from 40 deg. to 90 deg. or more. It is the limiting factor in high expansion practice. Reference to Fig. 6 will show what is implied in relation to cooling surface, and reference to Fig. 8 what it entails in circulating pump capacity, if the surface is invariable and restricted.

CONCLUSION.

Gases other than air—itself a merely mechanical association of several gases—alter the coefficients materially. This has its bearing upon manufacturing processes, but does not affect steam engine practice. Although no part of the subject can be said to be finally dealt with in this paper, enough may have been shown to stimulate others, who have facilities not possessed by the writer, to carry the matter to a conclusion.

The writer thinks it probable that tube length, diameter, temperature differences, and rate of flow will be found to be expressible by a general law; at times he has thought that he has glimpsed it, but hitherto he has been unable to crystallize it.

The chief conclusions are that—

(*a*) If high vapor vacua are required, air must be excluded.

(*b*) With high vacua, climatic conditions are potent limiting factors, and must be specially considered.

(*c*) In the absence of exact knowledge, the impossible has been attempted in design.

(*d*) Only by rational condenser proportion will it be possible to push the efficient expansion of steam to those limits that recent improvements in motors seemed to render easy of attainment.

APPENDIX.

Numerical example of the process of plotting a curve with ordinates in geometric ratio between two given ordinates.

Data.		Deg.
Steam temperature		110.00
Water temperatures	initial	67.00
	final	85.96
Initial steam and water temperature difference (first ordinate or term)		43.00
Final steam and water temperature difference (last ordinate or term)		24.04

$$\frac{\text{(Number of terms—1)}}{\sqrt{\frac{\text{first term}}{\text{last term}}}} = \text{common ratio} =$$

multiplier or divisor of an ordinate giving next succeeding or preceding ordinate.

Let 7 terms be required, then by logs.

$$\frac{7-1}{\sqrt{\frac{43.00}{24.04}}} = \frac{\log 43.0 - \log \text{ of } 24.04}{6} =$$

$$\frac{1.6334865 - 1.3809345}{6} = .04209 = \log \text{ common ratio } \therefore$$

Common ratio = 1.1018

Feet of Tube.	Term.	Log.	Ordinate.	Successive Differences or Efficiencies	Cumulative Difference (= Temperature Increment).
0,	1	1.6335,	43.003,	00.000,	00.000
		.0421			
1,	2	1.5914,	39.030,	3,973,	3.973
		.0421			
2,	3	1.5493,	35.424,	3.606,	7.579
		.0421			
3,	4	1.5072,	32.151,	3.273,	10.852
		.0421			
4,	5	1.4651,	29.181,	2.970,	13.822
		.0421			
5,	6	1.4230,	26.485,	2.696,	16,518
		.0421			
6,	7	1.3809,	24.038,	2.447,	18.965

And so on for succeeding decreasing terms. For increasing terms *add* log .0421 to 1.6335, and continue the process. Compare with the observed curve, Fig. 6.

THE CARRIERS OF PLAGUE.*

"PULEX CHEOPIS."

So long has plague in India been associated with rats that there is a proverb to the effect that "when the rats begin to fall from the roof, it is time for people to leave the houses." The Indian rat falls from the ceiling cloths and mud roofs of the Indian go-downs and bungalows and huts because it is a house rat and not a sewer rat like the English variety; and, consequently, the incidence of an epizootic of plague among rats in India is usually marked by the deaths of numbers of them in and about the walls and ceilings. And generally this appearance of plague among the rats is followed by the appearance of plague among human beings. But though there seemed thus an immense probability that plague among rats was transmitted to human beings, there has been great difficulty in proving it, and the difficulty lay in fixing on the means of transmission. This difficulty has been disposed of by the investigations of the latest scientific commission, which was appointed by the Indian government, and which is still pursuing its work. So important are the results of its first year's investigations, and so decisive are they, that they have been published as an interim report in the Journal of Hygiene. They establish definitely the fact that the chief carrier of plague from rat to rat, and from rat to man, is the rat flea, *Pulex cheopis*.

The commission, instituted by the Indian government, at the instance of Dr. Martin, F.R.S., Director of the Lister Institute, comprised Major Lamb, and Capt. Liston, of the Indian Medical Service; Dr. Petrie, and Mr. Sydney Rowland, of the Lister Institute, and several Indian investigators of plague, Mr. Kasava Pai among them, lent by various Indian States. The commission had to set about its work from the beginning, and unprejudiced by the conflicting experiences and theories of preceding investigators. For, although evidence in support of the connection between plague among rats and plague among human beings has accumulated since the discovery of the plague bacillus by Yersin and Kitasato, there have been many negative results in the attempt to demonstrate the belief positively. Most of the observers who have studied the question on the spot—Yersin, Ogata, Simond, Thompson, Koch, and Gaffky—have arrived at the opinion that from an epidemiological point of view plague is to be regarded as a rat disease in which human beings may participate. The relationship of the epizootic among rats and the epidemic among human beings has been particularly studied with great care for the outbreaks in Sydney by Ashburton Thompson (1902, 1903, 1904); in Port Elizabeth by Blackmore (1902); in Hong Kong by Hunter (1904); as well as in Cape Colony by Mitchell (1906); in Queensland by Baxter-Tyrie (1905); and for Calcutta by Pearse (1905). In India the connection was scientifically indicated, if not established, by Snow and Weir (1897), Hawkin (1898), and the German commission (1899). But as late as the report of the last Indian Plague Commission (1903) no definite conclusion was reached as to the share which rats take in disseminating plague. (The introductory preface in commenting on the contradictory nature of the evidence, remarked that it was not clear whether rats contracted the disease after its appearance among the human community, or whether they introduced it, or even whether it was shared by human being and rat alike.)

There have been similar difficulties in determining how the infection was conveyed from rats to human beings, or from rats to rats. One way of conveying the infection would arise from the cannibal practice which rats betray of eating one another's dead carcasses. But it has been shown that a very large amount of plague-infected carcass absorbed in this way is necessary in order to contract plague, and in any case man would not contract the disease in this way. That insects were the carriers of infection occurred to several investigators. Yersin (1894), Hawkin (1897), Nuttall (1897), Ogata (1897), and Simond (1898) examined flies, ants, fleas, and bugs, and found plague bacilli in their bodies, but though Simond succeeded in conveying plague from rat to rat by means of fleas, there were a number of unsuccessful experiments, and this want of success was recorded by Nuttall and Tidswell, and by the German Plague Commission, and by others who believed in this method of transmission. A few theorists objected to the hypothesis on other grounds; the chief of which was that the rat-flea was indigenous to the rat, and would not bite human beings or other animals. These objections have been finally disposed of by the identification of the characteristic rat-flea as *Pulex cheopis*, and by the proof that it will, and does, bite other animals.

We shall make the process of proof most clear by recording briefly the results of the experiments made by the Plague Commission. (1) It was first shown by confining rats in separate wire boxes, so that they could not come into physical contact, that plague could none the less spread from a plague-infected rat to a healthy rat. (2) It was shown that plague might be conveyed to guinea pigs in the same way. (3) On the other hand, close contact of plague-infected animals with healthy animals did not give rise to an epidemic (epizootic) among the healthy animals if fleas were excluded. Nor did plague-infected animals, if the same principle of exclusion was observed, convey the disease to the young they were suckling. (4) When, however, fleas were admitted to the colony of animals the epidemic, once started, spread from animal to animal, the rate of progress being in direct proportion to the number of fleas present. (Special precautions eliminated the possibility of air-borne infection in these experiments.)

That plague can be conveyed from animal to animal by means of the rat-flea was thus shown, together with a presumption that this was the principal means of conveyance. This presumption is strengthened by other experiments. It is shown both directly and indirectly that in a plague-infected house the infection may be due to the presence therein of rat-fleas, which are capable of transmitting the disease to animals. The direct proof was obtained by allowing guinea pigs to run free in plague houses which had been previously disinfected, but in which there were still fleas—as was shown by their subsequent discovery on the guinea pigs. The guinea pigs contracted plague, and the fleas caught on them were found capable of conveying plague to healthy animals. When guinea pigs, placed in a plague house, were isolated in gauze-covered cages in such a way that fleas could not reach them, the guinea pigs did not contract plague. If in a cage where they could be reached by fleas, the guinea pigs died in several cases. The microscopic examination of the fleas which the guinea pigs attracted in plague houses revealed the presence of the plague bacillus in their intestines.

One indirect testimony to the superior effectiveness of the flea as a vehicle of plague was afforded by the experiments made with regard to the infectivity of plague localities on the floors and walls of plague houses—irrespective of the presence of fleas. The plague bacillus disappeared from floors and walls much more quickly than had been thought probable. It remains to record the possibility that other insects besides fleas may convey the infection, and a suggestion (noted in the preface to the report) that plague may be a disease of fleas.

* Knowledge and Scientific News.

A common impression prevails that it is dangerous to employ abnormally high temperatures, or to apply heat in too concentrated a form to boiler furnaces owing to the liability of the furnace plates or tubes to become overheated and seriously weakened, rendering the boiler unsafe to work. The researches of Blackyunden, Durston, Hirsch, Witz, and Miss E. M. Bryant, B.Sc., amply prove that this idea is entirely without foundation, provided the heating surfaces are kept clean and the internal surfaces free from scale and grease, and these are essential conditions of first importance in any boilers designed for high duty.

[Continued from SUPPLEMENT No. 1613, page 25849.]

HOW SEEDS ARE CARRIED.—III.*

III. SEEDS CARRIED BY ANIMALS AND BIRDS.

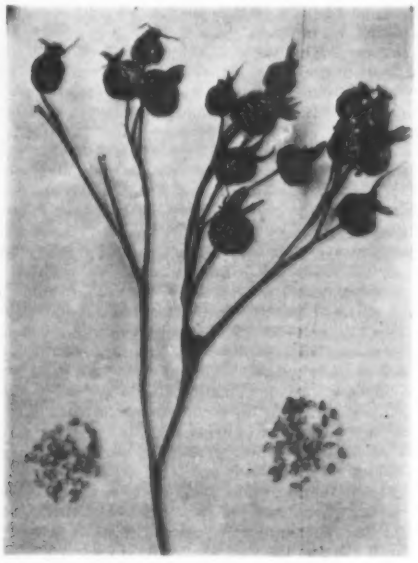
By CRAIG S. THOMS.

THE different departments of nature are strangely and beautifully in league with each other. While plants, seeds, and nuts furnish food for birds and animals, birds and animals help in distributing seeds and nuts.

The co-operation, though very frequently so, is not always friendly. The carrying of a prickly bur in an animal's fur coat is not a pleasant task, nor is it done willingly. Animals do not live on burs, nor often on the plants which bear them, so that by carrying the prickly seed capsules they are not performing a task specially advantageous to them. In nature, however, the brotherhood of service is large and generous; each creature works in his own sphere to render service to the whole.

Every child is familiar with the cocklebur weed. Who has not heard of the "dog with the burs in his tail"? And who has not with great patience extricated the hard, brown, hook-covered seed capsules from the tangled fur of his own pet canine? These two-seeded burs are carried by sheep, goats, dogs, wolves, and many other animals. A tame coyote belonging to a friend of mine used to break loose occasionally and hide in a near-by cornfield. He was invariably found with his fur full of cockleburs.

It is well known that wild animals usually keep themselves sleek and clean. When these burs get into their fur, as soon as opportunity allows they pull them out with their teeth. I have seen a dog thus pull them out of his tail, literally combing the long hair between his partly closed jaws.



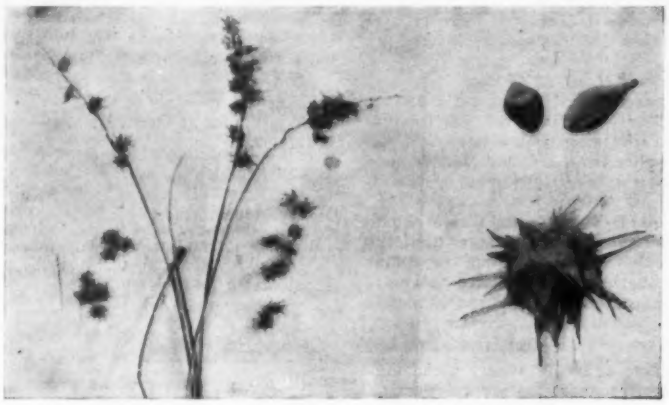
ROSE HIPS, SHOWING SEEDS.

In case of the cocklebur the bur has to be pulled from the fur and dropped to the ground before the seed can grow.

With the burdock, however, the case is different. The bur, though carried in the fur of animals in the same way, is composed of several rows of lanceolate, hook-tipped bracts. These bracts inclose, often some-

BEGGAR TICKS WITH ENLARGED SEED AND SEED CAPSULE, SHOWING HOW THESE SEEDS ARE BLOWN OFF BY THE WIND AND CARRIED BY ANIMALS.

what loosely, as many as a dozen seeds—I have counted sixteen in one bur—and these seeds, not being held in a closed capsule, as with the cocklebur, are often shaken out as the animal runs. The burs of the burdock have a way of hooking on to each other, like children taking hold of hands, so that they are seldom removed from the plant singly. Bunches of them are often found matted together in some animal's fur. In this there is an advantage to the plant, for in such a bunch, not only do the openings of the burs face every way, but a protuberance so large is sure to be squeezed when the animal lies down on it, or when it is gripped by the teeth. Thus the seeds are squeezed out and left to grow. Indeed, any animal that uses the teeth in extracting them from its fur will often tear the burs to pieces, thus scattering the seeds.



HEDGEHOG GRASS, SHOWING SEEDS AND THORNY CASE, ENLARGED.

WILD RYE, SHOWING AWNS WITH THEIR SEED.

Perhaps the most annoying bur both to man and beast is that of the hedgehog-grass, in many places called the sandbur. The one or two seeds are inclosed within small, hard burs that bristle with stiff spines. These spines, which point in every direction, are rough, and cling at the slightest touch. When the grass upon which they grow is ripe they are very easily detached and cling to one's trousers or stocking. For the inexperienced to pick them from his garments with his fingers is to have the thorn-points pierce the skin, first of one hand then of the other, then in desperation to grip them with the teeth and blow them out of the mouth, and as a sequel to have the fingers ache for days with the spine-tips left behind.

These burs, growing as they do on grass that is semi-decumbent, are often trodden upon by large animals like horses and cattle. They pierce the soft parts of their feet and are carried until the thorns are broken off.

When the grass is vigorously shaken by the wind, or disturbed by animals, many of these burs fall to the ground where they are trodden upon by wolves, coyotes, and other animals, and carried in their footpads, where the thorns break off and sometimes cause great discomfort.

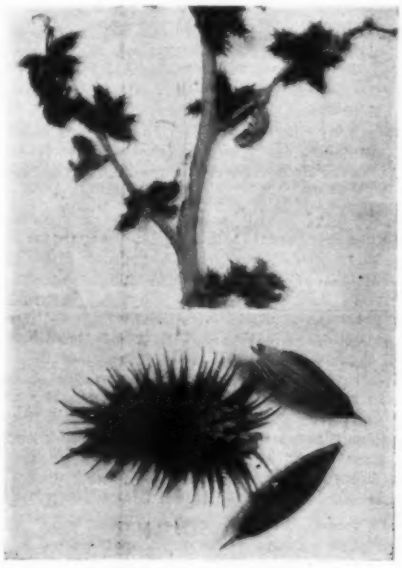
There are two burs with which nearly all lovers of out-doors are familiar—beggar-lice and tick trefoil. They grow in the woods, mix with the brush, and often literally plaster one's garments as he searches for late autumn flowers or winter game.

In case of the first, each round bur is composed of four beggar-lice which fit into each other like the four quarters of a cut apple, having their backs only covered with hooks, and each one breaking off separately.

In case of the second there are strings of flat pods covered all over with almost microscopic hooks, and united with very breakable joints. The plants on which both grow stand from two to four feet high.

There is no doubt that tick trefoil, besides being carried by animals and men, is also carried a short distance in winter by the wind. This is indicated by the very light, flat pods and easily detachable joints. Indeed, not a few seeds have both means of being carried. Of this class the beggar-tick is a good example. While it has two sharp prongs at one end of the seed capsule, which upon occasion attach to fur or clothing, the seed has a capsule so thin and flat and with such generous margin that it might almost be classed among the winged seeds. It is carried more by the wind than by animals, for in midwinter it is difficult to find a single head a part of whose seeds have not been blown away.

There are certain grasses also, of which the wild rye is a good example, whose seeds are doubtless carried to some extent by animals. The wild rye awns with their seed form a perfect trident with the seed in the center. The awns are not long, but are stiff and sharp for piercing and clinging, and the seed is fastened very firmly between them.



THE COCKLEBUR AND ITS SEEDS.

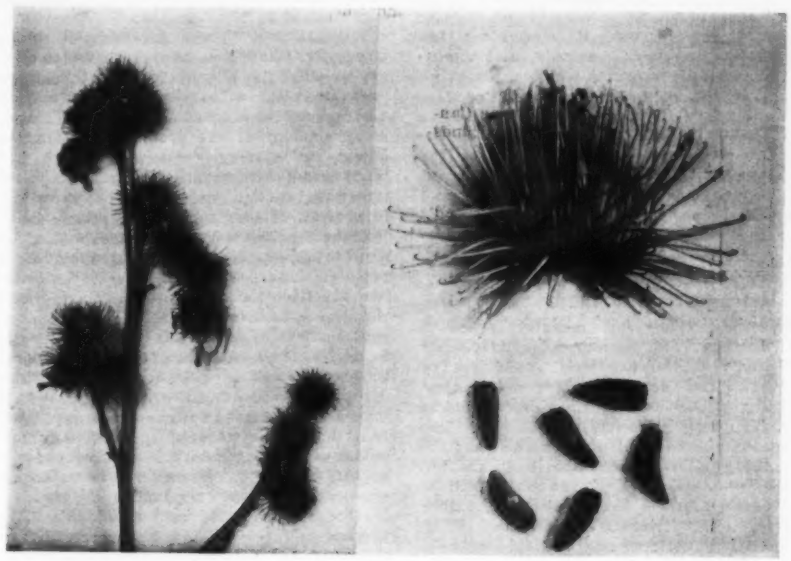
Nearly all kinds of soft pappus, designed to be carried by the wind, is to some extent carried by animals. One cannot be in the fields long where seeds are flying without finding pappus of various sorts sticking to his clothing. The soft down of anemones, milkweeds, cattails, cottonwoods, and willows cling readily to clothing or fur.

A BIT OF PAPER IMMERSED AMONG FLOATING DITCH STONECROP SEEDS, SHOWING HOW SUCH SEEDS WOULD ADHERE TO PLUMAGE.

Besides seeds thus carried by animals accidentally, many are scattered by them in their handling of food. Any one who has observed the habits of squirrels which live in a city or town and are half tame, cannot

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

but have noticed that while they eat on the spot a broken nut, they bury many whole ones, and seldom more than one in a place. Though squirrels in the wild have the habit of storing up nuts in considerable quantities, they also have this same habit of burying many singly. Many nuts, acorns, and pine cones thus buried are never dug up. They may not be needed, or may be covered with deep snow; and if the conditions be right they may grow the following spring.



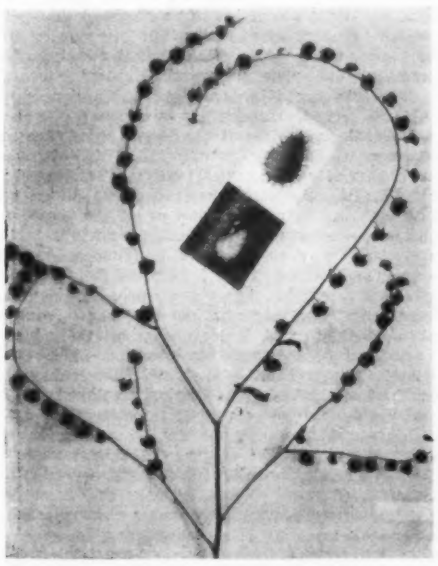
THE BURDOCK, WITH SEEDS AND HOOKS, ENLARGED.

Who has not seen the chipmunk seize a chokecherry, scamper away to a safe place, sit upon his haunches, deftly turn the delicate morsel with his paws until every shred of the succulent pulp was eaten off, then drop the stone and return for another, all unconscious that the stones would grow where they fell.

I have seen chipmunks with cheeks filled with bulbous roots which they were storing for the winter, and watched the small pine squirrels as they made repeated hurried trips with pine cones to some safe cache. Most of these roots and seeds are doubtless eaten, and those not eaten are stored too high or buried too deep for growth conditions. Yet, should an enemy surprise the squirrel he will drop the cone; and should a hawk capture the chipmunk the half dozen bulbs which his cheek pouches hold will grc where his bones are left to bleach.

When we consider that the time of storing for winter use is especially advantageous for raptorial birds and carnivorous animals to seize their prey on account of the way these small animals expose themselves in making regular trips for food, we can understand how not a few seeds are scattered in this way.

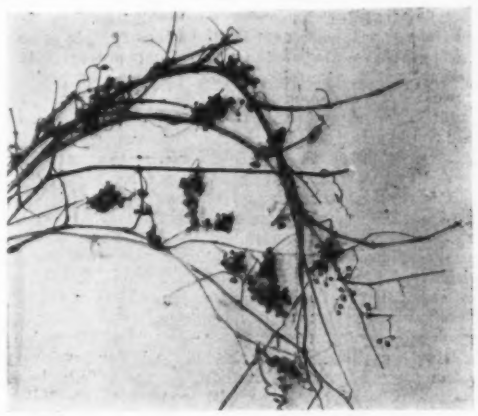
There is still another way in which animals carry seeds: Certain plants, such as melons, pumpkins, tomatoes, ground cherries, and the like have pulpy fruit which, especially after frost, becomes somewhat watery and sticky. With this sticky, watery substance the seeds are mixed, and it causes them to adhere to any animal that steps upon them or in any way breaks them open. A hog no sooner finds a soft, frost-bitten pumpkin in a cornfield than his nose is thrust into the middle of it, and a number of the seeds with their watery substance are landed on his nose and head.



BEGGAR LICE WITH ENLARGED SEED.

From one ground-cherry pod I one day took one hundred and fifty-six seeds, each one of them covered with a pulp so sticky that to touch a seed was to carry it off. When these plants are trodden upon, the pulpy fruit bursts, and the seeds are carried off by whatever comes in contact with them. The seeds of such plants are carried by any animals that eat them, accidentally step or lie on them, or in any way bruise them.

The part which birds perform in carrying seeds is by no means a small one. It has been proved by careful experiment that while few seeds eaten by animals will grow when excreted, the opposite is true of certain birds. Of course, such birds as the finches, whose bills are made strong for the very purpose of crushing seeds, and who live on the seed substance, are not useful as seed carriers; but it has been demonstrated that from seventy-five to eighty per cent of



WILD GRAPES IN WINTER, SHOWING HOW THEY CLING TO VINES AND SUPPLY BIRDS WITH FOOD.

seeds excreted by such birds as robins, bluejays, thrushes, and bluebirds, will grow. These are the birds that eat cherries, raspberries, blackberries, grapes, blueberries, and scores of other fruits which hold either a drupe or hard seeds within pulpy substance. Though the drupes or seeds are swallowed with the pulp, the latter is the bird's food, while drupes and seeds grow where they fall.

It will be noted that fruit of the character mentioned is usually of some high color—red, blue, black, purple, scarlet, all contrasting strongly with green, as though to invite the birds to the feast and thus secure the scattering of the seeds. In winter also the large clusters of flaming bittersweet may be seen for a long distance.

Particular adaptations are sometimes seen in the taste of certain birds. For example, the woodbine is a climber and it is important that its seeds be excreted near trees upon which it can climb. Of the fruit of the woodbine the flicker—one of our woodpeckers who, like the rest of his tribe, usually lights upon the bole of the tree—is very fond. This fact doubtless goes far to explain why so many woodbine seeds are dropped near the base of trees. I suspect that the same relation exists between the flickers and wild grapes, which hang on the vines all winter, though I have not been able to verify it from personal observation further than to have noticed many flickers in winter where wild grapes were abundant; but of this fruit robins and other birds eat freely during the cold months.

The wild rose seeds are not only scattered by birds that eat the pulpy hips, but by the downward-slanting thorns that cover stems and branches, seed-eating mice are discouraged from ascending to the feast which these hips hold.

Certain birds, such as bluejays and nutcrackers, have the habit of storing food, and by them, as by squirrels, many nuts, acorns, and other fruits are buried, and, never being recovered, grow where they were secreted.

No birds are more useful in the work of carrying seeds than the water-fowl—ducks, grebes, coots, and their kindred. There are many seeds, some of them almost as fine as powder, which when wet stick to plumage, foot or bill. If a piece of stiff paper be dipped into the water in which these seeds are immersed one may do his best to shake them off, but they cling in spite of him. It is in the places where these seeds are plentiful that many of the water-fowl obtain their food by swimming and diving. The seeds adhere to their plumage and are carried to other ponds, lakes, or rivers where they are washed off or in preening the feathers are dislodged.

Birds like snipes, rails, herons, and bitterns, that wade in shallow water and mud in which many seeds are mixed, fly away with some of the mud clinging to their bills and feet, and deposit the seeds in other places.

(To be concluded.)

EARTHQUAKES.*

By CAMILLE FLAMMARION.

THE alarming eruption of Vesuvius was hardly over than the world was aghast at the earthquake of San Francisco. The Italian volcanic eruption lasted from the 5th to the 12th of April; and the North American earthquake began, at 5:13 on April 18, with a violent trembling of the earth in vertical, horizontal, and oblique oscillations, and, as we know, it caused the overthrow in the course of two or three minutes of the greater part of the "Queen of the Pacific," and it was followed by an immense fire. Four hundred deaths were the consequence, and the financial loss was computed at four hundred millions of dollars. This disastrous shock was followed by several others, notably that of April 20 and May 19.

California has always been subject to earthquakes. In a list of the seismic disturbances in California, Prof. Holden reports as many as 514 in the whole State, 254 being in the territory of San Francisco alone, and this only from 1850 to 1886. During the nineteenth century there have been ten serious shocks, and in 1868 a part of the town was destroyed.

The towns and villages on the zone of maximum of intensity were cruelly affected for the length of 180 miles, from Santa Rosa to Salinas.

The last eruption of Vesuvius and the earthquake of San Francisco, following the earthquake of Calabria, which continued from the 8th to the 15th of September last, the one in India on April 4, so replete with terrible consequences, and the many slight shocks observed everywhere, lead us to study these phenomena of nature by the help of the most recent investigations of science. The planet which we inhabit does not possess the apparent stability which it presents to the mind uninstructed by history and science. The intensity of seismic shocks and the elasticity of the terrestrial globe were seen in the great disaster of Assam. This earthquake, which was not less disastrous than that at Lisbon in 1755, took place on June 12, 1897, and the tremors of the earth not only spread from this spot to the antipodes, but they were registered again on the seismographical apparatus of India, after having twice made the tour of the globe, like the atmospherical and marine waves caused by the gigantic explosion of Krakatoa in 1883, which I showed in my special work on the subject.

The earthquake at San Francisco seems to have been of the same intensity and energy as those of Lisbon and Assam. It was registered by all the seismometers of the globe, and it was not till they had twice made the tour of the world that the tremors decreased in force. I have before me the diagrams of the oscillations in England (Birmingham), Belgium (the Royal Observatory of Uccle), Austria (Laibach, etc.), and they show the course of this wave. It passed Birmingham at 1:25, by Greenwich time. As

A BUNCH OF BITTER SWEET. IN WINTER THE SEEDS ARE FIERY RED AND VISIBLE LONG DISTANCES.

the time of 5:13 at San Francisco corresponds to that of 1:13 at Birmingham, we see that it only took twelve minutes to go from San Francisco to Birmingham. It

* Translated by Rachel Challice (member of the Astronomical Society of France) and published in Knowledge and Scientific News.

arrived at the same time at Brussels (Uccle), and a little later in Austria, where the apparatus registered an oscillation lasting from 2:30 to 3:30. The time of Central Europe is in advance of Greenwich time. Mr. Davison's study of the oscillations of Birmingham showed that a second registration followed the first in 3 hours 13 minutes, *after having made the tour of the whole world.*

If to the 40,000 kilometers, which represent the tour of the world, we add the 9,000 kilometers which separate Birmingham from San Francisco, we see that the first impulsion was powerful enough to cause a vibration which resounded at least to the distance of 50,000 kilometers.

The vibrations produced by the earthquakes are transmitted at a different rate of speed through the entire mass of our planet to that with which they pass along the external crust.

On February 2, the seismometer of the Observatory of Florence registered a disturbance 9,000 kilometers off; and on that day a submarine volcanic eruption and a tidal wave destroyed the town of Buenoventura, a port of Colombia, on the Pacific coast. I also stated, on March 7, that the central meteorological bureau of Vienna, in Austria, registered on the night of February 18-19, an earthquake 12,000 kilometers off, which proved to be the violent shocks at Martinique, Saint Domingo, Saint Lucie, and a part of the Antilles, and the recrudescent activity of the mountains of Peleus.

The shocks at San Francisco were remarkable for their length and their rotary character. The violent phase lasted forty seconds, but it was three minutes and a half before their registration was concluded by the apparatus of the Naval Observatory of Mare Island. Before their destruction, it was noticed that many houses had left the straight line. A whole street rose up like a wave several meters long. In Calabria and elsewhere, deep, open crevices were made by these dislocations.

Earthquakes vary as much in the distance of their effect as in the intensity. Some, like those of Lisbon in 1755, or Assam in 1892, are felt two or three million square kilometers away, and others do not vibrate farther than a hundred or ten square kilometers. In 1879, the inhabitants of Linthal, in Glaris, were thrown out of their beds, while fifteen kilometers from there nobody felt it. It has been generally supposed that earthquakes are the consequence of volcanic eruptions. This idea is evidently erroneous, and nowhere is it more proved to be wrong than in Japan.

Everybody knows that Japan is *par excellence* the land for earthquakes, as it has as many as three or four a day. But the most unstable regions are not by any means those contiguous to Fusiyama, the great Japanese volcanic mountain, which, moreover, has been quiet for the last three hundred years. No eruptive manifestation accompanied the great seismic disturbances of 1891 and 1897, but many earthquakes have taken place in regions not at all volcanic. At San Francisco, for example, there is no volcano; and there have been earthquakes in many other spots where the volcano is absent or where, if it exists, it has shown no activity. Seismic disturbances are not caused by volcanic eruptions, either near or distant. But the seismic disturbances and volcanic eruptions are both due to the pliant state of some region of the earth's crust.

*Seismic disturbances are always in the neighborhood of mountains. The most prolific regions are those of a steep decline. The regions of a slight decline are those which, at 200 kilometers from the sea, have only a slope of from five or ten degrees; and places where, at the same distance from the seashore, there is a steep descent exceeding three degrees. All the regions which are incontestably seismic have a fall of three to five degrees, particularly in Japan. Seismic centers abound especially where there are such contrasts as a steep submarine stratum terminating in a very abrupt terrestrial slope. There are constant disturbances along the crevasses. There is a shrinkage of the crust along the dislocations, and they provide, as it were, a safety valve for internal disturbances. In other words, the volcano and the earthquake are brothers and not father and son, as it has been thought for a long time in default of sufficient observation.

The secular cooling has induced folds and hollows of solidified external crust on the pulpy shell, which goes on contracting, so that these noises are not only rumblings, but they are accompanied by movements; for the enormous pressure from the interior induces upheavals and volcanoes. Heat, hot water, and steam, are all at work; ruptures of equilibrium are accompanied by puffs of elastic gas, showing the existence under our feet of a considerable tension, which is always ready for action.

Chains of mountains and maritime slopes result from the gradual cooling of the globe, the cracking of the crust, which, being forced to a base, descend more or less. These cracks cannot occur without some disturbances; and, as I said before, they occur constantly every day and every hour. We only notice the most violent ones, which bring disaster to us. But, as a matter of fact, earthquakes are regular and normal episodes in the life of our planet.

The new science of seismology has been created by statistics, agglomeration and classification of the documents. Alexis Peirey, a learned compatriot and colleague of the Academy of Dijon, made a catalogue of the thousands and thousands of shocks mentioned everywhere from 1844 to 1872. I tried to continue this catalogue in my review, Astronomy, from 1883 to 1888, with the help of my laborious colleague, C. Detaille. But those statistics took up so much room that we had to give them up. It has been continued for several years, with scrupulous and indefatigable care, by M. De Montessus, of Ballore, in the excellent Belgian review, Ciel et Terre. This mass of documents records more than 170,000 earthquakes, which give room for the study of seismological geography. According to the general synthesis of M. De Montessus, of Ballore, which embraces the whole world, it is seen that the terrestrial crust trembles nearly equally, and almost solely along the two narrow zones which cross at an angle of 67 degrees, the Mediterranean or Alpine Caucasian and the circum-Pacific circles. These two zones coincide with the two most important lines of the terrestrial surface. Earthquakes are common on the most mobile strips of the terrestrial surface, where great accumulations made have been dislocated and raised in the tertiary period, before the formation of the principal actual chains.

WORLD WEATHER.

By SIR JOHN ELIOT, K.C.I.E., F.R.S.

THE Meteorological Office has recently issued a memoir entitled "The Life History of Surface Air Currents: A Study of the Surface Trajectories of Moving Air."* It gives the results of the investigations of Dr. Shaw, Director of the Meteorological Office, and Mr. Lempfort, his scientific assistant. The research marks an important advance in the scientific work of the office, and suggests that in future improvement in the practical work of forecasting will be based on the results of scientific investigation rather than on empirical or experimental inferences. It is, however, of special importance as it employs novel methods for the investigation of air movement on the large scale—which are leading to results not merely unexpected, but opposed to the fundamental principles which have formed the chief stock-in-trade of meteorologists during the past fifty years.

The most important principle hitherto utilized by meteorologists is that connecting pressure of gravity forces and air movement. It is usually stated in the form that air invariably moves from positions of higher pressure to those of lower pressure (the pressure being reduced to sea-level equivalents). In the other form (a development of the pressure) air is assumed to move along planes of equal pressure, inclined to the horizontal, or from positions of higher to lower level, and hence under the action of gravity. In addition to these laws and modifying their application is the principle first largely utilized by Farrel, that air moving on the rotating earth is always being deflected to the right of its path by a force or amount depending on its velocity and latitude position on the earth's surface; but *not* on the direction of the movement. It is apparently assumed that air never moves from positions of lower to higher pressure, or from positions of lower to higher level. This is certainly, more especially in the latter case, opposed to ordinary dynamical principles and experience. For example, the bob of a pendulum moves for one-half of its period of a single oscillation from higher to lower level under the force of gravity, and during the second half from lower to higher level with respect to the horizontal plane. Similarly, if the actual air motion be assumed to take place along an isobaric plane it follows that it may not only move down the plane from higher to lower level (acquiring momentum and kinetic energy), but also if it possesses momentum it may move in the opposite direction from lower to higher level (losing kinetic energy). Similar arguments might be applied to the pressure principle. The preceding remarks are simply intended to show that if ordinary dynamical (not hydrodynamical) principles are applied to meteorological investigation, their limited application in the form usually adopted by meteorologists is apparently neither valid nor justified by dynamical methods. Meteorological problems are chiefly problems of air movement, as changes of temperature, and humidity, rainfall, etc., are primarily the results of air movement. Hence the necessity for the study of the phenomena of air movement, from theory as well as from observation.

Air movement on the large scale may be that of the permanent or periodic circulations (as, for example, the trade winds and monsoon winds), and that of anti-cyclonic or cyclonic conditions, more or less temporary in character, and in their most acute form, termed in ordinary language, "storms." The chief features of the first class of air movements have been determined both from observation and theory. The movement undoubtedly depends upon large temperature differences between the equatorial and polar regions, or between sea and land areas. With respect to the air movement in cyclones and anti-cyclones there is, on the other hand, much diversity of opinion. Meteorologists, for example, differ as to the conditions necessary for the initiation and development of cyclonic storms, the transformations of energy which occur during the storms, and also of the actual features of the air movement. Farrel, on the whole, the most distinguished American meteorologist, resolves the air movement of a cyclonic system into circular movement about a moving center on a rotating surface. On this assumption he explains the incurvature of the winds and the contrast of the intensity of movement in different quadrants of the storm. The initiation of cyclonic storms is ascribed by him to temperature differences, and he classifies them into storms with a central warm area, and with a central cold area. The leading German meteorologists, we believe, now hold that cyclonic storms are mere incidents in the larger atmospheric circulations, just as a whirl in a stream of running water is a mere eddy in the general stream movement, and due to some slight local obstruction or other cause.

With respect to the diversity of opinion on this point, Dr. Shaw, in his memoir, remarks: "I think I am justified in saying that meteorologists are even not quite clear as to whether the circulation of a revolving storm as shown on weather maps is the primary element of the problem, the *fons et origo malorum*, or is merely an exaggerated by-product of more general atmospheric currents, possibly in the upper regions, just as the eddy or the whirlpool is the by-product of the flowing stream and its boundaries." Dr. Shaw's criticism of the vague and careless employment of meteorological terms by meteorologists generally is both just and deserved. In connection with his investigation he especially instances the use of the terms barometric minimum and movement of a barometric minimum, pointing out that they are used to designate phenomena of different orders, and hence to suggest similarity when there is no similarity. It is, on the one hand, universally admitted that pressure is never absolutely uniform over any large area, and that it is in a state of constant flux or change by amounts differing from place to place due to a variety of actions, of which one is the movement of storm areas or barometric minima of a definite type. It is, for example, possible in a hot country like India for pressure on one day to be lowest in, say, Sind, on the next day in northeastern India, and on the following day in Burma, or the Deccan. Weather charts drawn for short intervals of, say, one hour, might indicate the gradual transference of the seat of lowest pressure from Sind to Chola Nagpur, and the Deccan. But to treat this apparent transfer by the same methods and subject to the same general laws as the movement of the center of an intense cyclone is absurd, as it assumes similarity of conditions and actions where no such similarity exists. The changes of pressure accompanying the advance of cyclonic storms appear to be mainly due to internal actions, whereas in the other class of barometric minima referred to they are chiefly the result of external actions. Hence, to employ Dr. Shaw's words, "Treating the apparent displacement of all barometric minima generally in the same manner tends to obscure rather than to elucidate the difficult problems associated with the origin and march of storms."

How far this confusion taints the results of many meteorological investigations can only be surmised. It is, however, certain that more exact definitions and methods of investigation are essential for the progress of the science of meteorology. Assuming that there are cyclonic storms having a definite continuous existence and associated with certain peculiarities of air movement, the investigation of the motion of the air masses within the storm area or passing through it is evidently a problem of the greatest importance. Hitherto, chiefly due to the almost exclusive study of daily weather charts, little or nothing has been done to trace the continuous movement of the air masses affected by the cyclonic storm. The movement of the center of the storm or of the isobars or the direction of the winds in relation to the position of the center with respect to that of the position of observation, have hence been carefully studied from the charts, but these results tell us nothing of the previous or future history of the actual air mass passing over the place of observation, and hence throw little or no light on the conditions which determine the changes of temperature, humidity, and rainfall at the place of observation. Meteorologists are now agreed that what are called circular storms are not circular in the proper sense of the word. There is not merely a flow of air round, but also convergence toward a central area. There is also a large upflow over and near the central area, and also an outflow above and a descent probably in the outskirts of the storm area. The motion is hence successively complicated. It is also very variable, as squalls and gusts of the most violent character may alternate with strong but less destructive winds. Also in the cyclonic storms of the temperate regions of the northern hemisphere, the winds in the same quadrant of cyclonic storm, and hence from the same general direction, differ largely in their meteorological character (that is, temperature, etc.). These differences are, as Dr. Shaw has now shown, due to the previous history of the particular air mass in the given position of the storm in question. Hence the value and importance of Dr. Shaw's investigations.

The chief method of investigation employed is simple, but requires almost continuous registration of the air movement at a large number of stations in the area passed over by the storm. This is possible in the British Islands, as self-recording anemographs are in operation at many places. The path of a given mass of air is worked out from their observations by a step-by-step method. The following gives a statement of the method by means of a particular case. Suppose at a place the 8 A. M. observation shows that 20 miles of wind from W.S.W. has passed over it during the previous two hours. Half of this is assumed to indicate the movement of a mass of air during the previous hour (7 A. M. to 8 A. M.), and the remainder the movement of the same mass from 8 A. M. to 9 A. M. Suppose, then, an instrument observing at the new position shows that during the two hours preceding 10 A. M. 24 miles of wind from

* "The Life History of Surface Air Currents: A Study of the Surface Trajectories of Moving Air," by W. W. Shaw, Sc.D., F.R.S. (Director, Meteorological Office), and R. G. K. Lempfort, M.A. Published by the authority of the Meteorological Committee. (Wyman & Sons, H. M. Stationery Office, 1906; price 7s. 6d.)

S.W. has passed over it. It is then assumed that the previous mass of air will have moved 12 miles from S.W. to N.E. between 9 A. M. and 10 A. M., and the same amount from 10 A. M. to 11 A. M. These values are plotted on a chart, and inferences from similar observations from noon onward are made. The broken line thus obtained will give an approximation to the motion at the earth's surface of a definite air mass. The paths thus obtained are termed "trajectories" by Dr. Shaw. The method is undoubtedly only approximate, and subject to limitations. So far as we can judge, its employment is legitimate, and the conclusions thence established by Dr. Shaw and Mr. Lempfort are valid.

They have worked out a large number of trajectories for each of a series of typical storms which have passed over the British Islands in recent years, and formulated inferences of great interest and importance respecting the movement of air into or out of storm areas. The following gives a brief summary of what appears to us to be the most important of these conclusions: (1) In traveling storms, while in the front portion there is motion of the air from higher pressure to lower pressure, associated with falling temperature and with the gradual development of cloud and rainfall, there is also in the rear, sometimes from points quite near to the center, motion of air from lower pressure to higher pressure and higher temperature with improving weather, and again there are instances of motion with practically no change of pressure, temperature, or weather. Over the Atlantic, air moves generally from higher pressure to lower pressure, but sometimes from lower pressure to higher pressure. There are also instances of air moving for long distances with little or no change of pressure. (2) An essential difference must be drawn between fast traveling storms (as estimated by the ratio of the velocity of the center to the speed of the wind) and slow traveling storms. The former take all their air for the part which is represented by circular isobars from the region on the right hand or southern side of the path in the front of the storm and throw out an approximately equivalent amount on the same side in the rear. A slow traveling storm makes use of air from both sides of its path. That from the right hand or southern side flows directly toward the central portion, while that from the northern side curls round the rear of the storm. This difference in the characteristics of the two types cannot be accounted for by regarding all approximately circular storms as revolving vortices of air carried along by currents of different velocities. (3) In traveling storms the veering of wind is not generally a uniform sequence. Winds from some of the directions are relatively transient; on the other hand, winds from other directions are relatively persistent during the passage of the storm, even at considerable distances from the center; the transition from the one persistent direction to the other is comparatively sudden. In fast traveling storms the directions of the more persistent winds are S. or S.W. and N.W., while in the case of slow traveling storms the more persistent winds are E. to N.E. and S.W. to S. (4) On the eastern side of the Atlantic, surface air currents from the south are generally short lived, and soon disappear in the central portions of cyclonic depressions. Only in fast traveling storms do southerly currents continue beyond the path of the center and describe loops round the center. (5) Air currents from other directions than the south are much longer lived. They persist until either (*a*) they reach the trade winds, or (*b*) turn round the rear of a depression and approach the center from the southward, or (*c*) join a depression over the Western Atlantic. (6) The rainfall incidental to traveling storms can be, generally speaking, related to the ascent of air from the surface, as indicated by the convergence of the air, deduced from its motion, in a region not far distant from the locality of the rainfall, generally to the south or southeast of it. (7) The regions of high pressure that intervene between depressions and travel with them may be called anticyclones when we are dealing with a chart for a restricted area, but they are to be distinguished from the well-defined anticyclones which are persistent for days together. These latter are for the most part inert and comparatively isolated masses of air, taking little part in the circulation which goes on around them. (8) The motion of air with reference to the moving center of a cyclonic depression is not, as a rule, properly described as circular motion round the position of minimum pressure, modified by incurvature, and transformed into spiral motion about a moving center. The description would apply to the motion of air in the case of certain currents commencing on the northern side of a slow traveling storm, but the following cases of motion also occur: (*a*) in approximately straight lines leading toward the minimum or a point on its path in front, or on the trough line of a V-shaped depression, (*b*) round the minimum in curves, to which the minimum stands rather in the relation of the focus of a conic than that of the center of a circle.

Space does not permit us to discuss to what extent these conclusions, if valid, will modify the body of conclusions known as "the laws of storms," and hence the methods and practice of forecasting in the English Meteorological Office. In conclusion we congratulate the Meteorological Office on the results of the investigation. It is an example of the importance of research based on scientific methods which is now essential to further large progress in the improvement of the practical work of weather forecasting.—Knowledge and Scientific News.

THE LEAVENING MATERIALS EMPLOYED IN BREAD-MAKING.*

AT the present time scarcely any bread is prepared without the use of yeast or other leavening materials. The only exceptions are the Passover cakes of the Jews and the various varieties of unleavened bread used by uncivilized races. The former is made from a dough or paste consisting of flour, salt, and water. The common defect of these varieties of bread is that they lack a spongy texture, the steam which escapes during baking rendering them only imperfectly porous. Essentially, they are compact masses of dried starch-paste which scarcely deserve the name of bread.

The means now employed to produce the desired sponginess in bread are of many kinds; they may, however, be roughly classified as those in which living organisms cause the leavening, and those in which it is effected by chemical agents.

Among the former the spontaneous fermentation of the dough must certainly be regarded as the oldest. When flour and water are made into a dough and the latter is allowed to stand, fermentation soon sets in and carbonic acid is liberated. A thorough study of this process has been made by Wolffin and Lehmann.† They have found two distinct micro-organisms in the fermenting dough, viz., a variety of yeast and a species of bacteria related to the Bacillus coli commune which grows in beer-wort with the production of carbonic acid, hydrogen and nitrogen. Pure cultures of this micro-organism have demonstrated the fact that it is an acid-forming bacterium, the products of its activity including lactic and acetic acids. Inasmuch as the yeast cells are found only sporadically in the original dough the bacterium to which Wolffin has given the name of Bacillus levans must be regarded as the main factor in the spontaneous fermentation of this dough. This was also proved by inoculating dough prepared from sterilized flour with a pure culture of Bacillus levans. The fermentation thus set up yielded a mixture of carbon dioxide, hydrogen, and nitrogen in exactly the same proportions as in the experiments with culture media above mentioned. Analyses of the gases yielded:

	Per cent.
Carbon dioxide	66.5-67.6
Hydrogen	26.6-27.7
Nitrogen	5.8

Closely allied to this spontaneous fermentation is that of leavening dough. As is well known this leaven consists of a thin dough which is allowed to stand for several hours in a warm place. After the product (or rather the micro-organisms contained in it) has been repeatedly strengthened, it is added to the dough from which the bread is to be made. But while this process is very similar to the spontaneous fermentation of dough, the character of the fermentation is by no means the same. During the several stages of the preparation of leaven the yeast cells present in the original dough are supplied with fresh quantities of sugar, so that they multiply enormously and finally largely predominate over the fission-fungi. Hence the raising of dough by means of leaven distinctly differs from the spontaneous fermentation of dough in that it is caused by yeast, while the other is the result of bacterial action. That leaven really produces alcoholic fermentation was clearly demonstrated by Girard and Wolffin who have analyzed the gases resulting from it. These consist of 90 per cent of carbon dioxide, and a mixture of oxygen and nitrogen in the same ratio in which these latter gases exist in air. Hydrogen, which is the characteristic product of the action of Bacillus levans, could not be detected in any instance.

In order to distinguish still more sharply between the two kinds of fermentation, Wolffin made the following experiments. Samples of 100 grammes each of flour were made to ferment (1) by the addition of yeast, (2) by the addition of a mixture of yeast with a pure culture of Bacillus levans, and (3) without the addition of any ferment. Analyses of the resulting gases yielded the following results:

	With yeast.	Yeast and B. levans.	Without addit.
	Per ct.	Per ct.	Per ct.
Carbon dioxide	98.5	100	62.4
Hydrogen	0	0	37.6
Nitrogen	1.5	0	0
Carbon dioxide	..	87.8	75.3
Hydrogen	..	6.5	24.7
Nitrogen	..	5.7	0
Carbon dioxide	..	87.7	73.9
Hydrogen	..	7.4	24.4
Nitrogen	..	6.9	1.7

It is seen, therefore, that when both yeast and B. levans were added the production of hydrogen was either prevented or greatly reduced, which may be explained by assuming that the growth of the yeast takes place at the expense of the bacteria. At any rate the fermentation is essentially of the alcoholic type when considerable amounts of yeast are present.

As already pointed out the sour leaven should be frequently freshened by additions of flour and water. In well-conducted bakeries this is done several times a day. By thus introducing fresh supplies of sugar, a more vigorous growth of the yeast results, as has already been explained. Hence this method of keeping the leaven in a fresh state is an effective means of checking the production of acid and at the same time stimulating the growth of the yeast which constitutes the main factor in bread-raising.

Bread made with the aid of leaven is scarcely ever perfectly white. According to Mége-Mouriès, this is due to the fact that the fermentative acids convert the gluten of the flour into a soluble substance of slimy consistency, and which rapidly turns dark. It has been demonstrated, however, that it is possible to prepare perfectly white bread by means of leaven.

The leavening material most generally used is yeast. In former times the yeast employed for this purpose was top-fermenting brewer's yeast. In consequence of the greatly reduced production of top-fermented beers bakeries now obtain their supplies of yeast either from the distilleries, or, more recently, from special factories in which compressed yeast is manufactured.

Brewer's yeast of the bottom-fermentation type is not suited for leavening purposes; it contains bitter-tasting impurities and is too sluggish in its fermentative action.

The principal constituent of compressed yeast is the alcoholic ferment, Saccharomyces cerevisiæ. Besides this, however, it invariably contains acetic and lactic acid bacteria, but the action of these ferments in good compressed yeasts is always checked in the manner indicated by the experiments of Wolffin above referred to. The fermentation produced by compressed yeast is almost entirely of the alcoholic type; it never generates hydrogen.

Both leaven and yeast effect the raising of dough by generating gases, more particularly carbon dioxide. Very naturally the thought suggested itself to produce these gases by purely chemical means. Besides other advantages this would enable the leavening to take place without a loss of substance, such as invariably attends alcoholic fermentation. Exact experiments have shown that the average loss in fermenting dough is nearly 2 per cent. This loss is due to the escape of the alcohol and carbon dioxide which result, in nearly equal quantities, from the decomposition of sugar during fermentation. Attempts have been made to recover the alcohol by condensing the vapors escaping from the bakers' ovens, yet in spite of the costly experiments to this end conducted in the great army bakeries at Chelsea, nothing has been accomplished. It is estimated that more than 300,000 gallons of alcohol are annually volatilized in the bakers' ovens of London. It is very improbable, however, that any of this alcohol can ever be saved; losses are unavoidable where yeast is employed for bread-raising.

It is different where chemicals are substituted for the yeast. Among those who first advocated their use was the chemist Liebig.* His efforts in this direction were supported by calculations like the following. Assuming that the population of Germany (in Liebig's day it was about forty million inhabitants) daily consumed twenty million pounds of bread, then by avoiding the loss of 1 per cent due to fermentation, the use of chemicals in place of yeast would yield an increase daily of 2,000 cwt. bread; or, in other words, the same amount of flour would suffice to supply 400,000 people more with their daily bread.

Originally Liebig recommended the use of bicarbonate of soda and hydrochloric acid. One hundred pounds of flour were to be intimately mixed with one pound of bicarbonate; part of this mixture then, say one-fifth, set aside, while the remainder was made into a dough with 70 to 80 pounds of water, holding in solution 1.75 to 2 pounds of salt. To this dough 4.25 pounds of muriatic acid of 1.063 specific gravity were gradually added, and the reserved portion of the mixture of flour and soda kneaded into it. The dough was then formed into loaves and, after having been allowed to rise for one-half to three-fourths hour, placed in the oven.

Instead of hydrochloric acid, the handling of which involves certain risks, tartaric acid was subsequently proposed. One objection to its use is that the tartrate of soda resulting from its action on the bicarbonate is liable to impart an unpleasant flavor to the bread. Far better was the method proposed by Horsford,† in which the hydrochloric acid was replaced by phosphoric acid in form of its acid calcium salt, $CaH_4P_2O_8$.

Horsford's baking powder became extremely popular in America, and Liebig spared no pains to introduce it in Germany. He pointed out that its use not only does away with the loss of substance above mentioned, but actually restores to the flour part of those mineral nutrients, phosphoric acid and lime, which are abstracted from it in the milling process in the form of bran. Nevertheless the powder was never extensively used in Germany. It is sometimes employed in the household, particularly in the preparation of cakes, but the German baker appears to resent any attempt to introduce chemistry into his ancient trade. It should be admitted, on the other hand, that Liebig's view as to an increase in the food value of bread, by the use of Horsford's powder, was quite erroneous. Experiments have clearly shown that additions of mineral salts to bread are not utilized in the human body.

In the aggregate the losses due to the formation of alcohol and carbon dioxide are stupendous, but if we reflect that the individual baker bears only a small share of this loss, we cannot help but admit that, after all, the use of a good yeast presents so many advantages that our bakers can hardly afford to dispense with it. Baking powders may be advantageously used in very small bakeshops and where bread-making is not a regular occupation, as in the household.

* Pure Products.
† Centralblatt für Bacteriologie, vol. xv., 1894.

* Dingl. Pol. Journal, 187. 182 and 346.
† Chem. News, 1861, vol. ii., p. 174.

STEAM TRAPS.*

By W. H. WAKEMAN.

THESE appliances have proved worthy of adoption wherever steam is used for heating or drying purposes, also where long pipe lines must be employed for conducting steam to engines and pumps, as they save enough in a short time to repay their cost, thus proving a profitable investment.

Some steam users seem to think that a trap is only a luxury to be enjoyed by those who have expensive plants in operation and wish to show many extra appli-

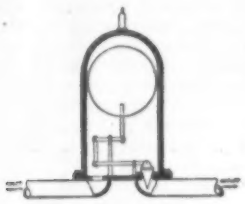


FIG. 1.

ances which might be dispensed with, and not be missed. This is a great mistake, as a trap is valuable according to the cost of fuel that must be burned to make steam. Whether the buildings and machinery are well made, or only the cheapest and poorest that can be found, and are kept in repair according to their first cost, thus constituting either a good or a poor plant, has no bearing whatever on the case.

Another point to be considered in this connection is that while exhaust steam is usually considered a waste product, it is not really so unless it cannot be used for any good purpose. There are scores of plants where

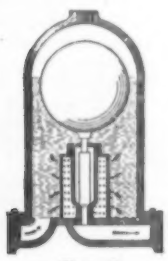


FIG. 2.

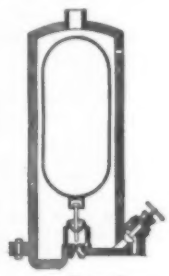


FIG. 3.

exhaust steam is allowed to waste, and live steam is used every day where dry exhaust steam would answer every purpose.

In some of these plants there are no valves for regulating the escape of steam, while in others that are fitted with them they are never used. The trap shown in Fig. 1 is suitable for this service, as it is intended for five pounds pressure or less. Water resulting from the condensation of steam enters at the left, filling the body of the trap until the large copper float rises and by means of connecting levers raises the top shaped valve, allowing water but no steam to escape at the right.

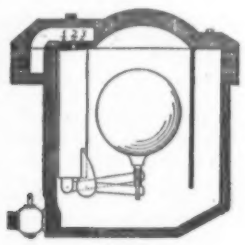


FIG. 4.

Steam cannot escape because there is always some water left in the trap. If it begins to run out faster than it comes in, the float falls and closes the valve at once, thus providing what is called a "water seal" that prevents loss of steam.

Traps may be divided into two general classes, namely: those that discharge constantly and those that must be filled, then are partly or wholly emptied by a dumping action which results in an intermittent discharge. As a rule the former type, to which belongs the specimen shown in Fig. 1, is well suited to light pressure work, and as there is a large space above

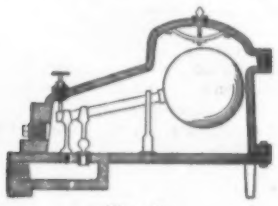


FIG. 5.

the float that is never filled with water, it gives an excellent chance for air to separate, and going to the top it is discharged through the air valve shown.

I had a rather interesting experience with a pair of these traps on one occasion, that appears amusing now that it is past. A certain heating system, forming part of the equipment of a large building, failed to work well and was considered a failure, as the pipes were made too small and the returns were too nearly horizontal to drain readily. These traps were fitted with a by-pass by means of which hot water could be shunted to the main return pipe without going through the trap, whenever it was necessary from any cause,

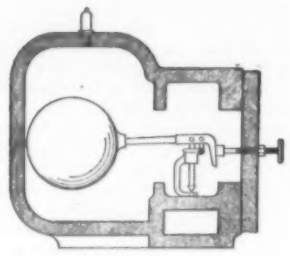


FIG. 6.

and in this case they had to be used all of the time, as the traps were not capable of removing this water fast enough to prevent pounding in the pipes.

Now the dome-shaped top of each trap is alike on all sides, except where the word "inlet" is cast on the lower part. This was investigated and found on the right side to outward appearance, and still the traps failed to work well. These tops are bolted to the bottom parts as shown, and although the bolt holes were spaced irregularly, giving the idea that they could only be used in one position, still it was possible to give them one-half turn on their bases, and still get the bolts in.

This is exactly what had been carelessly done in the shop where they were made; therefore, although the "inlet" denoted that they were right, they really were

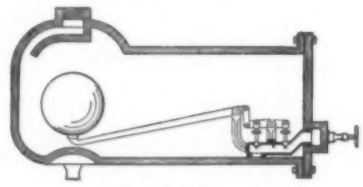


FIG. 7.

put on wrong and of course could not operate as the makers intended. Reversing the bottom connections proved a remedy, and they have worked well ever since the change was made.

Fig. 2 illustrates a very similar trap, except that there are no levers used. The valve is operated by direct connection to the float. An extra strainer is provided, because this trap is intended for separators and eliminators from which grease and heavy oils come down.

Fig. 3 illustrates another trap the valve of which is operated by direct connection to the float. The inlet is at the top and the outlet at the bottom, which is proper for places where there is enough "fall" to admit of such an arrangement, but in many cases the inlet and outlet

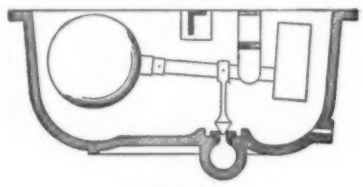


FIG. 8.

must be nearly on the same level. A blow-off valve is provided for, removing dirty water without taking the trap apart. The float in this case is not in the form of a sphere, therefore is not as strong as it otherwise would be, but is strong enough for all practical purposes.

Fig. 4 is another trap in which a spherical float is used, but is of very different design from those previously shown. The inlet is at the right hand near the top, but the float is protected from direct action of a stream of incoming water, by a baffle plate extending well toward the bottom of trap. As water must always cover the bottom of this baffle plate it forms an effectual water seal to prevent steam from blowing directly

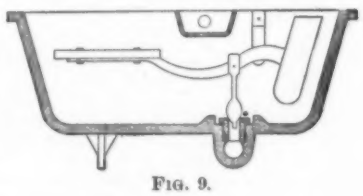


FIG. 9.

into the air, which is a valuable point in any trap, as it assists in keeping heat from going to waste.

As the water level rises the buoyant hollow copper float rises also, and at first it opens the valve marked 2, which allows some of the water to pass out, but if more comes than this valve can discharge, the float rises higher, the effect of which is to open valve 3, increasing the capacity. If this is not enough the float rises higher still, opening valve 4, which gives the full capacity of the inlet, therefore the trap is then working to its full limit.

It will be noted that this trap can be set where there is little head room above it, while others shown must be nearly all above the pipe lines which they drain. In either case, if the trap must be set in close quarters (and some of them are put where there is little chance

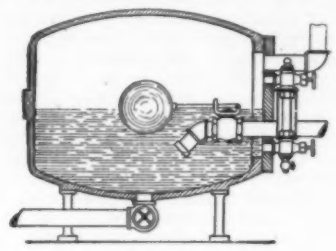


FIG 10.

to work around them), it is a good idea to use a union on each side so that when it is necessary to clean or repair the trap it can be taken down easily and placed on a bench or elsewhere and quickly taken apart, thus saving time and maintaining an even temper.

On nearly every one of these traps that I mention there is a packed joint, and unless care is taken to manage the matter right, this joint is not only a source of annoyance and labor but also an expense, because frequently an inferior packing is used that is torn into shreds when the joint is pried apart.

Of course the engineer cannot help this when a trap is new, but the first time he packs it ought to be the end of such trouble. Cut a gasket out of a standard grade of packing, put it on the joint with nothing between them on the lower side, then cover the upper side with Dixon's fine graphite mixed with enough cylinder oil to make a thick paste. Cover it carefully and rub it down until a good, smooth, shining surface is secured. It will take a few minutes to do it, but

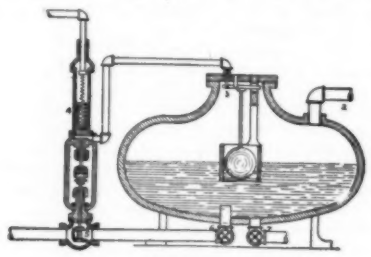


FIG. 11.

will be time well spent, for when it is necessary to break that joint again it will come apart easily, and the old gasket can be used without trouble or delay.

Fig. 5 illustrates a trap that can be used under high pressure (which is also true of Fig. 4) as the float is located at the end of a long lever, therefore the valve is moved easily. The inlet is at the upper right-hand end, while the outlet is at the lower left-hand near the floor.

The hand wheel shown is for the purpose of screwing down the spindle, the end of which bears on the end of float lever, raising it and opening the valve in case it is desired to blow out the trap under pressure. A plug is provided for the purpose of removing sediment that collects around the valve.

Fig. 6 is a compact form of trap the valve of which is operated by a spherical float, exerting a strong leverage. A hand wheel at the right operates a spin-

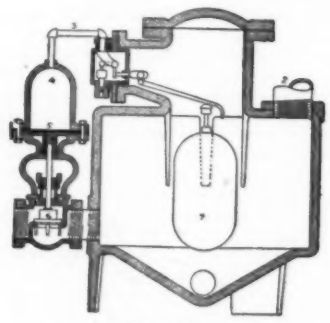


FIG. 12.

dle, the end of which acts as a stop for the curved end of lever, also provides a way for opening the valve to blow out water under pressure. A check nut is provided for locking this spindle in any given position.

Illustrations and explanations given in the foregoing matter show that a steam trap is a device for opening a valve to let water escape from a heating system of some kind, also for closing it when steam attempts to escape. Steam users can be found who have given this matter so little intelligent attention that they claim it is useless to provide such an appliance in their case, as a valve can be put on each drip pipe, and if the engineer is careful about giving these valves the required opening and no more, it will answer any purpose.

It is not claimed that this is impossible, as it can be

* Copyright 1906 by Joseph Dixon Crucible Company.

done, but it never pays, because a man could not properly care for more than two or three outlet pipes. If he attempted to care for more of them or tried to do other work also, water would collect in the pipes, or else steam would blow out more than it ought to. If the amount of condensation coming to a drip valve

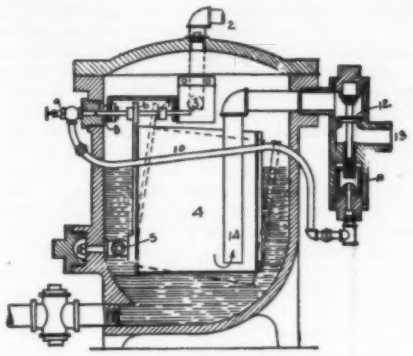


FIG. 13.

was the same all day, the matter would be much more simple, but it is constantly changing, therefore it requires automatic regulation and nothing else will answer the purpose.

Fig. 7 shows a trap that is fitted with a long lever operated by a float in the usual way, except that the

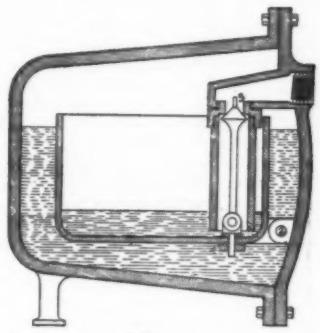


FIG. 14.

leverage is great, consequently the valves will be easily handled even when operating on a high pressure line.

It will be noted that there are two valves operated by an auxiliary lever that is pivoted centrally between them. One of these moves downward to open, while the other moves upward to secure the same result, therefore if pressure causes resistance to opening one it is counterbalanced by opposite action on the other.

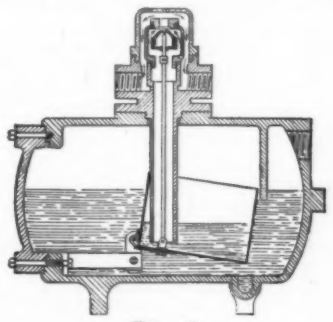


FIG. 15.

The inlet of this trap is directly over the float, which would naturally cause the incoming water to force the float downward. To overcome this objection a curved deflector is provided, thus shielding the float completely.

Fig. 8 represents a trap in which the weight of float and its lever is counterbalanced, thus rendering it

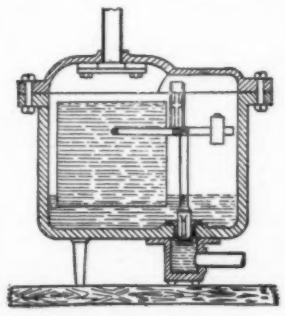


FIG. 16.

more sensitive to the effect of water entering to raise the float, open the valve, and discharge water.

While a hollow copper float is light and buoyant, thus rising quickly with the water level, there is always more or less danger of collapse under very high pressures. Even if a float does not collapse, water may slowly work into it until it becomes so heavy that it will no longer float but will sink as low as possible, thus rendering it entirely useless.

Fig. 9 illustrates a trap in which there is no copper float, making it entirely free from the above objection. The counterbalanced lever and valve are moved by means of a soapstone float, that cannot collapse or fill with water. However, the absence of a float does not necessarily mean that every trap so designed is intended for a very high steam pressure, as there are other points to be taken into consideration.

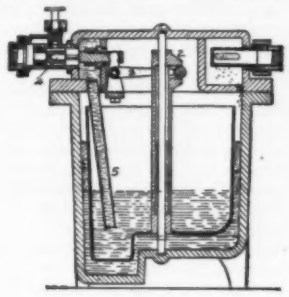


FIG. 17.

Every trap is sold on a guarantee to discharge the water of condensation coming from a stated number of square feet of radiating surface, although for sake of convenience the capacity of each may be stated in linear feet of one-inch pipe. In all such cases the steam pressure must be known, because water travels through a given pipe according to the head of water above it in hydraulic work, which is represented by

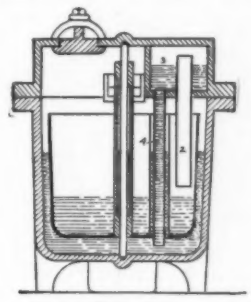


FIG. 18.

the steam pressure behind it in heating work.

From this it will be plain that if a given quantity of water must be disposed of for each hour that the plant is in operation, the inlet and outlet of the trap that is to discharge it must be proportioned accordingly. It does not matter so much about the size of the trap itself, as that is only an incident in the transaction, for although a large bowl or body would take more water to start with, still there would be no further

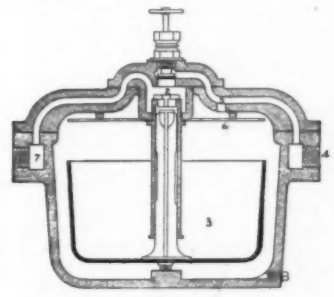


FIG. 19.

advantage to it; because it must then be discharged as fast as it is received, regardless of the capacity of trap so far as simply holding water is concerned.

When this fact is taken into consideration it will be plain to prospective purchasers that the size or bulk of a trap has no bearing whatever on its real capacity, which must be rated according to the quantity of water that it discharges per hour.

Furthermore, when a trap is guaranteed to discharge the water coming from, say, 10,000 feet of one-inch pipe, it is not so definite a statement as appears on

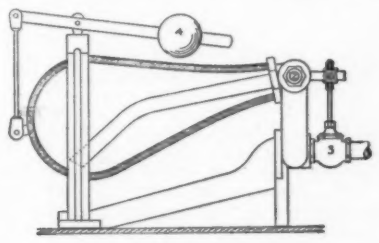


FIG. 20.

the surface, for under some conditions a given amount of surface will radiate much more heat than under others. If 10,000 feet of one-inch pipe are located in a well-built brick building, a certain amount of water will return from them, but if the same pipes are put into a worn-out wooden building full of cracks and breaks, the condensation will be more, and if the same pipes are subjected to the action of air forced into rapid circulation by a blower, the condensation may be five times as much as in the first case mentioned.

To illustrate this I may mention a case where the superintendent of a shop ordered a trap that was listed to discharge the water coming from a given number of linear feet of pipe. The amount of radiating surface was well within the limits designated, but when the trap was put into service it could not keep the pipes free from water, therefore it was pronounced a failure. Impartial investigation showed that air was forced to circulate around these pipes by a blower, therefore a very much larger trap was required to do the work. Such experiences should cause engineers to thoroughly investigate failures of every kind before

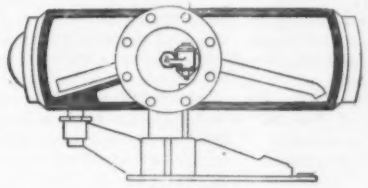


FIG 21.

condemning apparatus or appliances which may work perfectly when used under conditions for which they were designed and made.

Fig. 10 represents a trap in which water is received through a pipe in the upper part of the removable head, and is discharged through a similar pipe below it. This pipe is fitted with a balanced valve that is opened and closed by a float connected to a lever. The

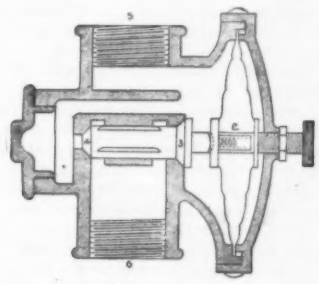


FIG. 22.

end of this pipe is several inches above the bottom of bowl, so that sediment is not readily taken up by it.

Steam pressure acting on the surface of water in the trap forces it out through the balanced valve as soon as the water level is high enough to raise the float, but when it falls a few inches this valve is closed again, while the end of pipe is still under water, making it impossible for steam to escape. A blow-off valve is located at the lowest part, and the whole bottom of the trap inclines toward this outlet, causing sediment to naturally work in that direction until blown into the sewer.

Fig. 11 illustrates a trap that is somewhat compli-

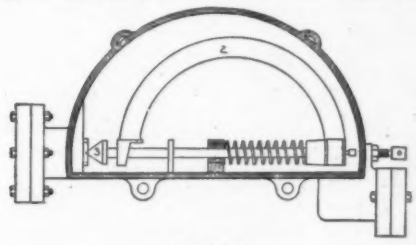


FIG. 23.

cated, but when used on high-pressure work it should give excellent results. It operates as follows: Hot water enters through the large upper pipe 2, and falling to the bottom rises until the float is lifted by it. This opens a needle valve 3, which admits steam to the lower part of cylinder 4, containing a piston as shown. Pressure accumulates under this piston and raises it against resistance offered by the spring. By means of a suitable rod which is partially shown, this piston raises the valve 5, and as the valve 6 is open whenever the trap is in operation, steam pressure acting on the water forces it out through 5 and

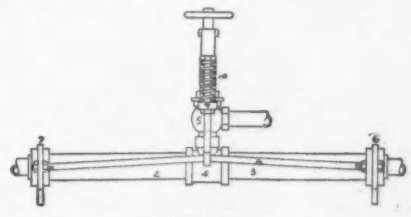


FIG. 24.

6 to the sewer, or to a receiver if it is to be used again.

Lowering the water level brings the float down and this in turn closes the valve 3, shutting off steam from the cylinder 4, therefore the spring forces the piston downward, closing 5 and preventing escape of steam. The valve 7 is for blowing mud out of the bowl.

Fig. 12 illustrates an ingeniously contrived trap for high-pressure work, the operation of which is as follows: Steam mixed with water of condensation enters at 2, the water falling to the bottom while steam fills the whole upper part, going out through the small pipe 3 into the dome 4, the bottom of which is fitted with a diaphragm 5, which is depressed by the pressure, thus holding the valve 6 to its seat as long as the float 7 remains in its present position.

As water collects in the trap, 7 rises and by means of suitable levers shown, shuts steam off from 3, and at the same time opens a small free outlet valve that exhausts all steam remaining in 4, consequently when pressure acts on the bottom of 6 it is raised from its seat, allowing water to be forced out of the trap very rapidly.

With some of the traps shown in this article, it is necessary to remove some of the connecting pipes in order to clean the internal parts. Where pipe-joints are "made up" with red lead it is difficult or impossible to break them without crushing the pipe or breaking it off, making it necessary to remove the broken pieces with a cold chisel, but if these pipe threads are thoroughly treated with Dixon's graphite properly prepared for the purpose, they can be taken out much easier and better.

Study of previous illustrations shows that some traps, fitted with floats to operate their valves, discharge continuously, while others are filling a portion of the time and discharge at intervals. The bucket traps that are to be presented next must of necessity discharge at intervals only, as it takes more or less time according to size of trap and amount of radiating surface to be drained.

Fig. 13 is a specimen of this type. Water of condensation enters at the rear as the trap now stands, through the pipe 2 shown in dotted lines behind the baffle plate 3, and falls to the bottom of the body of trap.

At this time the bucket 4 is supposed to be in the position indicated by the dotted lines as it is hinged at 5. Water continues to rise on the outside of the bucket (which is practically empty) until it overcomes the dead weight of the bucket, causing it to take the position shown by the full lines; and while it is in this position the outlet valve is closed so that no water can escape, but when the bucket fills and the extra weight is added, causes it to tilt downward a projecting ear, strikes the tappet 7 and opens a valve 8. The angle valve 9 being open, steam passes through 10 and is admitted to the bottom of piston 11, which is thus forced upward, carrying the valve 12 with it, thus opening a passage 13 to the atmosphere. Pressure acting on the water surface forces it out at 14 until the bucket is empty; when it tilts upward, the valves 8 and 12 are closed and the entire process is repeated.

Fig. 14 shows another but much more simple trap fitted with a tilting bucket. As shown, the bucket is nearly empty, and as it is hinged at 2, the rising water coming in through a pipe not shown, brings the bucket into the position illustrated in which the outlet valve 3 is closed. As the water continues to rise it overflows into the bucket and the weight causes it to tilt downward, the effect of which is to open the valve 3, when pressure acting on the entire water surface forces it out rapidly.

It always seems more natural to have the outlet from a trap flow downward and in some cases it is absolutely necessary for it to do so, but with the traps just described (and several other kinds), the waste water may be raised several feet above the trap. In fact, the only limit to the height is caused by the steam pressure carried, for it is possible to raise water two feet for each pound pressure behind it. It must be remembered, however, that this is pressure at the trap and not at the boiler, because friction of long pipes, of insufficient diameter and rapid condensation of steam, may make several pounds difference.

Another point to be considered is that where water must be lifted in this way the amount discharged per hour will be less than if it flowed away freely. Many of our cellars and basements are below the sewer, therefore it is frequently very convenient to have a trap that will raise water a few feet and do it easily.

Fig. 15 is another trap fitted with tilting bucket. As long as the bucket is in its highest position the outlet valve is closed, but when water overflows over into the bucket, causing it to sink, the outlet valve is opened and water is blown out or discharged.

There are some places where it is desirable to have a trap discharge continuously, as for illustration when taking condensation from radiators and banks of pipes in rooms where noisy apparatus cannot be tolerated, even if the noise is not loud enough to be noticed in shops and mills containing machinery that sings and purrs as it performs its work. Engineers who have always been employed in these shops cannot appreciate the requirements of school rooms, etc., where absolute quiet for a greater portion of the day is necessary.

On the other hand, there are places where an intermittent discharge is preferred, as for illustration where coils of pipe are located in vacuum pans and kettles used for boiling sugar to make candy. These coils are set in kettles so that the outlet is as high as the inlet, while much of the pipe is below both of them.

Condensation settles in the bottom of such a coil, accumulating flows to the trap, which fills and then discharges. While it is discharging it is practically the same as if there was no trap on the line, for there is a grand rush of steam and water through the entire coil, which effectually clears it, and the whole apparatus is in good order for further work. I do not claim that a continuous discharge trap cannot work in such a place, but all traps are not equally efficient in this respect, and it is a well-known fact that sugar can be boiled much better at given times than at others, although nobody engaged in the business may be able to account for the difference.

The difference in time required for the process of boiling, under different conditions, affects the cost not only in actual time required, but in cases where water collects in such vacuum pans and steam kettles it absorbs heat by re-evaporation which ought to go into the sugar to be boiled, and by prolonging the process the ingredients are sometimes spoiled, thus making delay a very costly luxury that is not appreciated. This makes it especially desirable to have a suitable trap in every case.

Fig. 16 illustrates a bucket trap in which the bucket is always full of water, operating as follows: The bucket is supported by a forked lever, as shown, which extends one-half way around the circle, at each end of which a stout pin is fastened to the bucket and passes through the end of lever. A counterweight is adjustable on the opposite end of this lever, so that when ready for use it is practically balanced.

Water from the heating system enters through the upper central pipe and falls directly into the bucket, causing it to fall as low as possible. When full, the water overflows into the body of the trap and, rising, brings the above-mentioned lever almost into equilibrium again by restoring the buoyancy of the bucket.

It will be noted that the outlet valve opens downward, consequently when the bucket and counterweight are almost equally balanced, steam pressure acting on this valve causes it to open and discharge water, but before all of it escapes the bucket falls and closes the valve, thus preventing the escape of steam.

I have noticed that the internal parts of all traps become corroded through the action of water standing in them. Although cast iron is freely used in the construction of these appliances it does not escape the general bad effects. Corrosion here appears in the form of half spherical blisters, inside of which is a small collection of black matter and underneath this the iron corrodes rapidly.

Such blisters are not formed by the disintegration or separation of the iron as in the case of a boiler plate, but by the collection of foreign matter. If this is removed and the whole internal surface covered with Dixon's fine flake graphite mixed with a small quantity of cylinder oil, and the mixture is well rubbed down to give it a good surface, there can be no corrosion until the graphite wears off. Of course, we cannot expect steam fitters who set up traps for other men to use, to interest themselves in such details, but where an engineer is superintending the installation and repairs of a plant in which he is to spend the greater part of each week, he should secure the best possible results by attending to all such matters himself.

Fig. 17 is a form of trap in which the bucket rises and falls in a straight line. Water enters at the right-hand side and at once passes through a small retainer that retains any foreign matter that is not wanted in the trap. This strainer can readily be removed for cleaning, by unscrewing the union just outside of the trap.

As water falls from this strainer it is caught in the small chamber below it, from whence it runs out through a passage close to the shell into the lower part of it, outside of the bucket. This causes the bucket to rise, carrying with it the slotted guide sleeve 2, which supports the inner end of the lever 3, the effect of which is to close the discharge valve 4, and keep it closed as long as the float remains in its highest position.

Water continues to enter until it partly fills the bucket and covers the lower end of pipe 2, Fig. 18, which is a view of the same trap except that it is taken at right angles to Fig. 17. Water will now be forced up into the small tank 3, and it thence falls into the bottom of the trap. When the bucket is nearly full its weight causes it to fall and open the valve 4, Fig. 17.

Pressure is now acting on water surface outside of the bucket, hence some of it is forced out through the discharge valve 4. Pressure also acts on the surface of water in the bucket, forcing it upward through the pipe 5 to the discharge valve 4. If it was now necessary to wait until slowly incoming water from the heating system raised the bucket, it would result in wire-drawing action on the discharge valve, as it would be partly open for some time, and this is not desirable, but water from tank 4, Fig. 18, flows down into the body of the trap through pipe 4, quickly raising the bucket and closing the discharge valve 4, Fig. 17.

Various catalogues, used to illustrate steam machinery and appliances, contain statements that are at least surprising to well-informed engineers. Take the following as an example: "Statistics show that 85 per cent of the energy of fuel is wasted. When you pay your coal bill you merely get 15 cents on the dollar. The greatest enemy to the economical utilization of steam is water. Hence it is an imperative necessity to dispose of it quickly." This statement is made in connection with the use of steam traps.

Of course, there are different ways of using and wasting steam, also various ways of calculating the same, but what conditions could possibly be found under which only 15 per cent of the value of steam would be used? We note that the great enemy is water, but are not told just how this bogus friend accomplishes these results. It is a well-known fact that some plants are heated by water only, and they are considered economical.

There are many plants in operation using a boiler pressure of 80 pounds. This steam is used in engines and pumps, after which it goes into heating systems where it is reduced to water at a temperature of about 200 deg. If there is not enough steam coming in this way, it is supplied directly from the boilers through one or more reducing valves.

The total heat of steam at 80 pounds gage pressure is about 1,212, and as the temperature of returning water is 200 deg., it leaves $1,212 - 200 = 1,012$ heat units to be supplied by the coal used. Ten pounds of this water is turned into steam by each pound of coal burned, therefore, $1,012 \times 10 = 10,120$ heat units are accounted for from each pound of coal burned. Coal that contains 14,000 heat units per pound is considered a very fair grade, then $10,120 \div 14,000 = 0.72$. In other words, 72 per cent of this coal is actually utilized, which is an important advance over the 15 per cent just mentioned.

Much of the remaining 28 per cent is used in creating chimney draft, or is lost through boiler settings out of repair. Even this shows a wasteful condition of affairs, but there is no necessity for exaggerating the facts which are well known to engineers.

Fig. 19 illustrates a trap in which the outlet valve 2 is open as long as the bucket 3 is in the position shown. Hot water enters at 4 and as the valve on top of the cover is closed, it goes through the inlet 5 and falls upon the deflecting plate 6, which prevents it from falling directly into the bucket. It fills the lower part of the trap and, rising, lifts the bucket 3 until the valve 2 is closed. As it continues to come it overflows into the bucket and causes it to sink, thus opening the outlet valve 2 and quickly discharging water through the passage 7.

Several traps have now been described in which a bucket made of cast iron is used to open and close one or more valves for the purpose of disposing of accumulated water. These buckets are as good as any other known device for this purpose, but they must be very thin in order to be light enough to float in water, consequently if one of them is cracked by rough usage in carting, or by uneven contraction and expansion in service, it will not hold water, hence becomes useless.

On many of the traps already shown and described, a glass water-gage is provided for the purpose of showing how much water is present, and whether the internal mechanism is operating to good advantage. Whether gages are beneficial or not may be an open question, or at least whether the good points overbalance the bad ones, but if there is one on a trap it is an easy matter to shut it off if not wanted, therefore on general principles it is well for an engineer to take all that is offered in this way, then if some of the extras are not required every day he can let them remain out of service.

The objections to a water-gage are that it takes time to keep it clean, replace broken glasses, and when a glass breaks in an out-of-the-way place (as many traps must be located where they are seldom seen), it may discharge steam and hot water for some time, causing damage to machines, belts, etc., before it is discovered. The advantage secured by use of them is that it is possible to tell at a glance whether a trap that is so equipped is working well or not.

If a stationary trap is not fitted with a water-gage it is possible in some cases to detect failure to operate, after an engineer has had experience with that particular kind of trap, but when a tilting trap is adopted its actual condition can be determined at any time. Fig. 20 belongs to this class, as the pear-shaped bowl is hinged at 2, and while in the position shown the outlet valve 3 is closed. Water is now running into the trap, but the weight 3 is still sufficient to hold the bowl in position. When this is nearly full of water its weight overcomes the leverage of the ball and the large end of the bowl falls to its lower position. This opens the discharge valve 3 and water is quickly discharged.

This may be classed as a continuous discharge trap, so far as taking water from a heating system is concerned, for when the bowl is up as shown, it takes water freely, then as it fills and goes down the discharge valve opens, but there is no other valve to close at this time, therefore water from the system can go directly out of the discharge valve 3.

Fig. 21 is another specimen of the tilting traps. It is hinged at 2, but this is not at the center, as one part is longer than the other. Water enters through a trunnion on one side and escapes through another on the opposite side. So far as metal in this trap is concerned, the shorter end is heavier than the other, hence when empty it stands in the position shown.

When water comes in it flows to the left-hand or shorter end, holding it in this position until water enough has accumulated to cover the shelf, then it overflows and goes to the right-hand or longer end. Here the greater leverage causes the body of trap to tilt, throwing the right-hand end down, the immediate effect of which is to throw water from the left to the right-hand end, giving a greater leverage to open the discharge valve, and as pressure acts on all water surface it is quickly forced out through the discharge trunnion.

Fig. 22 operates on a principle that is entirely different from those already explained in this article. The diaphragm 2 is made of phosphor bronze and partly filled with a peculiar fluid, the composition of which is a trade secret. When heated this fluid flashes into a vapor, the expansive force of which is great. When in this condition it is adjusted to hold the balanced double valve to its seats at 3 and 4, thus preventing the passage of steam through it. When cooled the vapor returns to a fluid, thus contracting and being greatly reduced in volume, creating a partial vacuum in the diaphragm. The effect is to draw the valve stem out and open the valve.

In practice this operates as follows: The drip pipe from a heating system is connected to 5, and 6 is the

outlet from trap. When cold the valve is open; therefore as steam is first turned on, the air and cold water which is usually discharged first passes through freely, but when warm water and then steam comes, the resulting heat expands the diaphragm 2 and the valve is at once closed as seen in the illustration, thus preventing the escape of steam. When water collects in the trap again, the diaphragm opens the balanced valve and the process is repeated.

Another trap which is operated by the expansion and contraction of fluid is shown in Fig. 23. It is contained in the curved tube 2 and when heat imparted by steam strikes it, expansion takes place at once and the valve 3 is closed. When water collects in the trap, contraction opens the valve and the process is repeated as long as steam is on the heating system.

Fig. 24 is still another trap that is operated by expansion and contraction, but in a different way from those just described. The body of this trap consists of two pieces of brass pipe 2 and 3, screwed into a tee 4 which also supports the valve 5. Each end of the brass pipe carries a coupling with a yoke, 6 and 7. On each side of the body of the trap there is a curved rod, only one of which is seen in the illustration at 8.

When steam heats the body of this trap at 2, 3, and 4, it expands, the effect of which is to draw 9 downward against the tension of the coiled spring 10. This action closes the valve and shuts off steam. As water collects the trap cools and contracts, thus allowing the spring 10 to open the valve and let the water out.

There is one point in connection with all traps operated by expansion and contraction, to which special attention is called, as failure to observe it has caused much trouble.

Do not locate one of these traps near a steam pipe belonging to the system to be drained, or to any other system, as heat from it will keep the trap warm and consequently expanded, preventing it from operating well. Always locate such a trap in as cool a place as practical and it will do good work.

Every trap ought to be painted with a kind of paint that will stand the severe test of changing temperature, as the nature of the work calls for these changes, therefore they ought to be covered with two coats of Dixon's silica-graphite paint.

This concludes our description of steam traps, including the float bucket, tilting, and expansion types, which it is hoped will prove both interesting and instructive to those who have not given this subject the attention due to its importance.

DATA ON FUSES.

ONE of the principal features of the fuse is its overload time element. Before a given current will heat up the fuse metal to its melting temperature a fixed time must elapse. This time lag, as it is commonly called, rapidly decreases as the current increases.

There is a common impression that fuses and overload circuit breakers have practically the same characteristics, though such is not the case. The overload circuit breaker depends for its operation upon the quantity of current, while the blowing of a fuse is dependent both upon the quantity of current and upon the time during which it is applied. The circuit breaker will open immediately at any overload in excess of its setting, but will not operate at any smaller current, no matter how long continued. Standard fuses, on the other hand, will operate, in time, at as small an overload as 25 per cent, and will open in a proportionately shorter time with greater overloads.

In determining the proper size of fuses to protect any apparatus, the overload time element should be considered in connection with the smallest current likely to prove dangerous. The low cost and the overload time element of the fuse render it particularly suitable for the protection of motor circuits, as it will carry a certain overload for a short time, but will open if the overload continues.

For alternating-current motors, taking a starting current much more than the full-load value, fuses which would carry the starting current would not give much protection except against a short-circuit. In order, therefore, to afford adequate protection, a second set of fuses is necessary. These fuses should be switched into the circuit after the motor has come up to speed. When thus used they may be of suitable capacity to give much better protection to the motor.

The use of two inclosed fuses in parallel is not advisable unless sufficient resistance is placed directly in series with each fuse to render the contact resistance of the fuse negligible. Fuses have such low resistance that equal resistances in the two branches cannot be insured except by the arrangement just mentioned, as the resistance of the contacts would be proportionately large. When branches of unequal resistance are in parallel the two fuses do not carry equal currents, and are likely to open the main circuit at a current less than their combined carrying capacity.

The various types of open-link fuses which have been in common use for a number of years are objectionable, as the fuse metal is exposed, and there is a considerable flash and throwing of fuse metal when the fuse operates under heavy overload or short-circuit. This has made it necessary to inclose such fuses in cabinets, except when installed in places where the flash and hot metal can do no harm. Also, open-link fuses cannot be very accurately rated on account of the exposure of the fusible strip. It was to overcome these objections that the inclosed type of fuse was developed.

The inclosed fuse consists essentially of a fusible element inclosed within a tube filled with a material to exclude the air and to facilitate the opening of the circuit when the fuse blows. Suitable terminals are provided so that the fuse may be mounted in a fuse block.

Complete lines of inclosed fuses were developed by several manufacturers, each make of fuse having different dimensions from those of other makes. This often made it very difficult to obtain fuses for renewals, as the corresponding capacities of the different makes did not have the same dimensions, and hence could not be used in the same fuse block. On this account dangerous substitutes for fuses were frequently used. Furthermore, inclosed fuses were not uniformly rated, as some makes were rated at about their maximum carrying capacity, while others were rated at about 80 per cent of this amount, making a difference of 25 per cent in the carrying capacity.

So much confusion resulted from the lack of uniformity of the commercial types of fuses that finally a conference was held between the representatives of the Underwriters National Electric Association and the fuse manufacturers, for the purpose of adopting standard requirements for inclosed fuses.

Standard dimensions and test requirements were prepared for 250- and 600-volt fuses. These requirements are given in the 1905 edition of the National Electric Code, under Rules 52 and 53. Fuses constructed in accordance with the standard are known as National Electric Code Standard fuses. The dimensions of the fuses have been carefully worked out, and are as small as it is safe to make them. Standard fuses are now made by all the principal fuse manufacturers, and are interchangeable in all National Electric Code Standard fuse blocks of corresponding capacity. The use of fuses of special dimensions, and particularly those smaller than the standard, should be discouraged.

Much credit is due to the members of the Underwriters committee for their work in the preparation of the standard, and to the various fuse manufacturers, who gave their hearty co-operation.

The standard divides inclosed fuses into classes, according to the voltage and ampere capacity, and specifies the dimensions for each class, so that a given fuse can be used only in a fuse block of its class. The fuses are rated so that they will carry 10 per cent overload indefinitely, and will open at 25 per cent overload.—From the Electric Journal.

ENGINEERING NOTES.

The production of pig iron of all kinds in the United States in 1876 was 1,868,961 gross tons. In 1905 it was 22,992,380 gross tons. The production of Bessemer pig iron was not separated statistically from other pig iron until 1887. In that year it was 2,875,462 gross tons, and in 1905 it was 12,220,209 gross tons. The production of basic pig iron was first separately ascertained in 1876, when it was 336,403 gross tons. In 1905 it was 4,105,179 gross tons, charcoal basic pig iron not being considered in either case.

When the blast furnace is charged with coal or coke for melting the contents a heated air blast is forced through the furnace. The air is heated to about 200 deg. F., and the pressure is from 5 pounds to 10 pounds per square inch above the atmosphere. Formerly this gas was burned at the top of the furnace, but now it is utilized for regenerative purposes, to raise steam in gas-fired boilers, and (after it has been properly washed, cleansed, and made cool) it is used to drive gas engines. It is estimated by competent authorities that for every ton of iron about 70,000 cubic feet of gas are available for driving blowing engines. A gas engine consumes about 130 cubic feet of blast-furnace gas per brake horse-power per hour. The composition of this gas depends upon what fuels, fluxes, and ores are used. The heating value of the gas is about 100 B. T. U. per cubic foot at atmospheric pressure and 60 deg. F. The use of this gas for driving gas engines is of quite recent date, and the first plant is believed to be that operated in Glasgow in 1895. It is of interest to note that Thwaite—who so long advocated the use of gas engines and the utilization of blast-furnace as well as producer gas—had the satisfaction of seeing a Thwaite-Gardner purifying plant installed. It is only necessary here to point out that it is essential that crude gas from coal-fed blast furnaces should be well washed, scrubbed, and cooled before being used in the gas engine, or there will be trouble from tar.

No producer can be regarded as up to date that does not embody means of automatically adjusting the amount of water or steam admitted together with the air into the fire bed in fixed proportions according to the load, since without this arrangement, the fire will grow dead at the lower loads and the engine will not be able to pull up to a higher load again when necessary. While the ordinary anthracite and coke producers show a general similarity at least in type, the bituminous coal producers and such as burn lignite and peat, offer a striking variety of forms. We have such taking air in from below the grate, or from its circumference, or from a central pipe, and others having the fire on top and taking air from above. Still others have two fires and take air from both sides. With the double zone producer as developed by Fichet and Heurty in France, and by the Deutz Motor Works and by Koerting Brothers in Germany, lignite or peat is the most desirable fuel to use, especially in form of briquettes. The raw fuels may also be burned provided that they do not contain over 20 per cent of water, since otherwise the upper zone of combustion is apt to gradually wander down and therefore a second grate has to be inserted. However, lignite and peat containing excessive moisture are of little importance beyond the field of their production on account of the high cost of transportation. The double combustion process in itself is very simple. In the upper layers the coal is transformed to coke, the unstable gases being discharged through the incandescent zone where they are transformed to fixed gases. The coke thus formed is burned up in the lower fire after it has been extinguished for some time in the middle zone on its way downward. The gases formed below are, of course, stable and are drawn off together with those from above.

ELECTRICAL NOTES.

A new hydro-electric plant of some size has lately been installed in the south of France. It lies upon the Siagne River, a mountain stream in the Alpine region near the coast, and is intended to work in connection with the extensive set of overhead lines which a French company, the Energie Electrique du Littoral, is now operating. Several plants in the Alpine region such as Entraygues, Mescla, Plan du Var, and others are now giving current for many of the cities and towns along the Riviera in the region of Nice, Monte Carlo, Cannes, and Toulon. With the new Siagne plant it is proposed to extend the power distribution as far west as Marseilles, thus giving a system which is one of the most important on the Continent. We have already spoken of the Entraygues plant, which gives current for Toulon. The present station is intended to work with it, in order to give a greater supply, or if need be it can be connected with other overhead lines. The hydraulic work, carried out by the Giros and Loucher firm, comprises a dam erected on the river, which here flows between rocky walls. After passing by a settling basin, the water is taken to a point just above the electric plant by an offtake canal which gives a flow of 600 gallons per second. The canal ends in a large basin which stores up the water as a reserve supply. From the basin, two penstocks of 37 inches diameter lead down the side of the mountain to the electric plant. At a point just above the station the two penstocks separate into five larger and two smaller ones to supply the turbines. The plant uses a water head of 1,140 feet, and the water feed is estimated to give 7,000 horse-power net. In the station are erected Thomson-Houston alternating-current dynamos, coupled direct upon the shafts of 1,500-horse-power turbines, which are placed alongside, with a heavy flywheel between. Three-phase current at 11,000 volts is given by the dynamos, which run at 375 revolutions per minute. For exciting the fields of the alternators there are two small turbo-generators, and besides the plant uses two small dynamos for the local lighting and power which are coupled to the same turbines. Step-up transformers raise the current to 30,000 volts for some of the overhead lines, while other lines use the 11,000 volts from the machines.

In an article entitled "How the New York Edison Company Uses Its Own Laboratory," in the Electrical World, the very complete system of electrical automobiles is described which the company uses for its own purposes. There are in all fifty-one cars of various descriptions; nine of these are passenger cars, one of which is used by the paymaster making his rounds to the various stations, sub-stations, and offices, and five are for the use of superintendents. Thirty-four delivery vans are provided for carrying general supplies and for delivering arc and incandescent lamps, and eight heavy lorries are provided. The number of persons regularly employed in the automobile service is ninety-five, exclusive of the gangs which accompany the trucks and erecting wagons. A special automobile station and repair shop has been established where the automobiles receive a general inspection and the batteries a close examination and test every night. A very complete record is kept of every car and its equipment. Each vehicle has a job number and everything done to the vehicle in the way of repairs, etc., is charged against it, so that by this means the company knows exactly what each vehicle costs. Daily records are kept of the mileage traveled, condition of battery and tires, length of charge and the amount of repairs, and this record is complete for each machine from the time it was bought. A small repair department is maintained, but most of the heavy work is done in the general repair shops of the company close by. One of the 2,000-pound wagons is a high-speed vehicle for night emergency work. These vehicles carry a repair gang and complete emergency supplies and look after all emergency work, such as burn-outs, break-downs, etc. Six of the wagons are used by the arc lamp department for erecting arc lamps, fixtures, etc., and for installing electric signs. An erecting gang accompanies each wagon. The wagons carry arc lamps, globes, shades, and the necessary paraphernalia for erecting lamps and signs. The gang consists of five men and a foreman. There are three three-ton trucks, one of which is used for general delivery work. The other two are used by the arc lamp department for erecting city lamp posts, etc. These trucks carry a gang of five men and a foreman, besides the iron posts and the erecting material. Portable electric drills form part of the equipment. Five five-ton trucks are used for hauling heavy supplies and carting cables, reels, etc., throughout the city. Each of these trucks is equipped with an electric winch which is used for drawing the cables into the underground street conduits. The erecting gang which accompanies each of the trucks consists of eight men and a foreman. These

large trucks are also used during the winter months for thawing out frozen water pipes. By this means it is not necessary to tap any feeders, and frozen water pipes may also be thawed out where there are no electric supply mains at all. The charging switchboard at the automobile station consists of two boards, each equipped with thirty charging plugs. Each panel is equipped with a double-pole, double-throw switch and rheostat. Readings of the ammeter are taken every hour. The energy is supplied from the Waterside station at 220 volts. This is brought in on the three-wire system so that one board is connected on the negative side and the other board on the positive side of the system.

SCIENCE NOTES.

A question closely associated with that of nitrogen, if not intimately connected therewith, is that of the importance of humus in relation to fertility. It has been recently stated by an eminent experiment station director that "the mineral elements form but the skeleton of the soil, and without humus, which gives life and activity, are practically useless as a medium for plant growth." This statement is an attractive one, and may be in a broad sense correct, but, notwithstanding all of the investigations that have been made, it is very probable that much has yet to be learned as to the function of humus and the influence it exerts in the maintaining and improving of the fertility of our soils. We are unable from our present knowledge to state whether the effect is physical, chemical, or biological, or whether it is a combined effect of each, or whether it is absolutely essential that the organic matter be present in large amounts, in order that the best results may be obtained. It is a problem well worthy of the attention of our agricultural chemists, and one which must be solved on a scientific basis if we are to give safe advice as to the cultivation of our soils.

In a paper read before the Académie des Sciences, M. Janssen, the well-known astronomer, gave a report upon the work carried out at the observatory on the summit of Mont Blanc during the year 1906. This year was favored with an especially fine season and many good scientific results were obtained. At the beginning of summer, M. Beaudoin, the government architect, constructed a shelter house which is separate from the observatory so as to afford a refuge for persons during all seasons. Some enlargements and improvements have been made in the observatory itself so as to allow of a long stay on the summit. The observers can now make a longer stay without suffering so much from the altitude. In July, Messrs. Moog and Guillemard made some biological researches upon human beings and upon rabbits and guinea pigs relating to blood corpuscles and altitude, which will appear in a special paper. During July and August M. Millochau, astronomer of the Meudon Observatory, and M. Milan Stefanik remained at the summit for thirteen days in order to carry on some special work upon the sun, and a paper has been prepared by Millochau and Feiz upon the calorific emission of the sun, using the Feiz pyrometric telescope in solar work. M. Senonque made researches on magnetism at different altitudes, replacing his meteorograph by a new instrument. M. Alexis Hansky, of the Pulkova Observatory, came from Russia for the purpose and made observations with M. Stefanik upon the surfaces of Jupiter and Venus. Owing to the great clearness of the air they obtained good results with the large telescope of the observatory.

During the twenty years 1851-1871, considerable advance was made in technical education. In Switzerland the Federal Polytechnicum at Zurich was founded in 1851, destined to contest with Berlin the honor of being the greatest technical school in Europe. In England the Department of Science and Art at South Kensington, London, was organized in 1853. In Austria, a technical school at Budapesth, Hungary, was begun in 1856. In 1863 technical institutes were organized at Milan and Naples. In Germany, the Stuttgart school had risen to the rank of a Technische Hochschule in 1862, and the Darmstadt school in 1868. At Aachen a new school was organized in 1870. In the United States the most noteworthy events were the founding of the Massachusetts Institute of Technology in 1861, and the passage of the Morrill Land Grant in 1862, the beneficial effects of which upon technical education we are now enjoying in almost every State of the Union. In Norway, Mr. H. Christie, of Christiania, submitted to the Storthing in 1868 his famous plan for technical education in Norway—a plan embracing technical, Sunday, and evening schools for mechanics, elementary technical schools of a practical character, and a polytechnic institute of the highest grade at Christiania. This plan has since been put into execution and upon it as a basis the technical education of Norway has developed. In the same year, 1868, the Imperial Institute of St. Petersburg was reorganized as a higher technical school. During this span of twenty years the general tendency was toward a higher and more scientific grade of instruction. Schools which started in an humble manner gradually took on the characteristics of modern technical education. As the year 1851 marked the first feeble efforts, so the year 1871 is noteworthy as the date when development, as we now recognize it, began with a vigor and an impetus which have given results remarkable from any point of view—the increase of the number of students, the money expended, the character of the schools, or the enhanced industrial efficiency.

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TABLE OF CONTENTS.

PAGE

I. BOTANY.—How Seeds Are Carried.—III.—By CRAIG S. THOMS. —16 illustrations. 25860

II. CHEMISTRY.—The Leavening Materials Employed in Breadmaking. 25863
The Manufacture of Sulphuric Acid: The Contact Process.—2 illustrations. 25867

III. ELECTRICITY.—Data on Fuses. 25867
Electrical Notes. 25867

IV. ENGINEERING.—Engineering Notes. 25867
The President at Panama.—1 illustration. 25863

V. GEOLOGY.—Earthquakes.—By CAMILLE FLAMMARION. 25861

VI. MECHANICS.—An Automatic Carbonic Acid Gas Starter for Automobile Motors.—3 illustrations. 25866
Objections to High Crane Speeds. 25866
Steam Traps.—By W. H. WAKEMAN.—24 illustrations. 25864
The Newman Variable Speed Gear.—By EMILE GUARINI.—2 illustrations. 25867
The Prevention of Engine Wrecks from Cylinder Water. 25866
Feed-water Purification.—By R. J. STROHM.—1 illustration. 25864

VII. MEDICINE AND HYGIENE.—The Carriers of Plague. 25869

VIII. METEOROLOGY.—World Weather.—By Sir JOHN ELIOT, K.C.I.E., F.R.S. 25862

IX. MISCELLANEOUS.—Science Notes. 25868

X. STEAM ENGINEERING.—Air in Relation to the Surface-condensation of Low-pressure Steam: An Experimental Study of Condenser Problems.—III.—By JAMES ALEX. SMITH. 25868

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